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৪৯তম স্পেশাল বিসিএস (শিক্ষা) বিষয়ভিত্তিক প্রস্তুতি

বিষয়: প্রাণ রসায়ন (৬০১)

Compendium PDF

(সিলেবাস অনুসারে সর্বাধিক গুরুত্বপূর্ণ টপিক ও এমসিকিউ-এর সমন্বয়ে রচিত)

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প্রিয় শিক্ষার্থী, ৪৯তম স্পেশাল বিসিএস (শিক্ষা)-এর বিষয়ভিত্তিক পর্স্তুতি প্রাণরসায়ন অংশের নির্ধারিত সিলেবাসের অন্তর্ভুক্ত সকল ক্লাস সম্পন্ন হয়েছে। আসন্ন চূড়ান্ত পরীক্ষাকে সামনে রেখে লাইভ এমসিকিউ একাডেমিক টিম আপনাদের প্রস্তুতিকে শাণিত করতে বিশেষ কমপেনডিয়াম পিডিএফ প্রদান করছে। এখানে যা যা থাকছেঃ

Most Important Topics of Biochemistry for 49 Special BCS

Part-I:

Marks-50

A. Biophysical Chemistry

(i) Atomic structure: Fundamental particles, atomic number, atomic mass, isotopes, relative atomic mass, atomic models.

(ii) Periodic property: **ionization potential, electron affinity and electro negativity.**

(iii) **Gas laws, Ideal gas equation, Dalton's law of partial pressure, van der Waals equation.**

(iv) Thermodynamics: **First** law of thermodynamics, **enthalpy**, **entropy** and free energy change.

(v) Solution: **Osmosis and osmotic pressure**

(vi) Acids and bases**: Brown stead-Lowry concept of acids and bases, Lewis concept, neutralization, pH, Buffer, biological buffers**, buffering capacity.

(vii) Spectrophotometry: **Beer-Lambart laws, optical density**

B. Organic Chemistry

(i) Aliphatic compounds: Hydrocarbon, Alkanes, alkenes, alkynes-their **properties and reactions. Alcohols, aldehydes, Ketones, carboxylic acids** and derivatives: **chemical properties and reactions.**

(ii) Aromatic compounds: **Aromatic hydrocarbons, nitrobenzene, aromatic amines, phenols-their structures, properties and reactions.**

C. Biomolecules:

(i) Carbohydrates: **classification**, some important polysaccharides-**Starch, glycogen, muco-polysaccharides-their structures and functions.**

(ii) Proteins: **Classification of amino acids**, their **structures** and properties, **essential amino acids**, classification of proteins, **Sequencing of proteins.**

(iii) Lipids: **Classification**, biological function, **essential fatty acids,** role of phospholipids, cholesterol in membrane formation.

(iv) Nucleic acids: **Classification of nucleic acids-DNA double helix, other structures of DNA. Types of RNA-their structures and functions.**

D. Nutrition

(i) Classification of food, **SDA, RQ.**

(ii) **Nutritional diseases**

(iii) Vitamins: **Classification, recommended daily allowances, deficiency symptoms** and **functions of different vitamins. Coenzyme activity of Vitamin B Complexes.**

(iv) Minerals and trace elements: Biochemical functions, and **deficiency symptoms.**

BIOCHEMISTRY

Part-II

Marks-50

A. Intermediary Metabolism:

(i) Enzymes: **classification, active sites, Michaelis-Menten equation, significances of Km and Vmax, Inhibition of enzymes, Allosteric enzymes.**

(ii) Carbohydrate Metabolism: **Glycolysis, TCA cycles, Gluconeogenesis.**

(iii) Lipid metabolism: **oxidation of fatty acids, ketone bodies**, production of energy by **complete oxidation of palmitic acid.**

(iv) Protein Metabolism: **transamination, deamination** and **glucogenic and ketogenic amino acids, urea cycles.**

B. Physiology:

(i) Blood: **composition**, function, **blood cells**, blood grouping, **Heart structure and coronary heart diseases.**

(ii) Digestion: Digestion and absorption of carbohydrates, proteins and fat.

(iii) Structure and **functions of liver, lung and kidney.**

C. Endocrinology:

Classification of hormones, mechanism of hormone actions, **physiological functions and biochemical functions of Pituitary, thyroid**, parathyroid, pancreatic and **gonad hormones.**

D. Clinical Biochemistry:

1) Diagnostic importance of **ALT, AST, CK, LDH, acid phosphatase, alkaline phosphatase, urea, uric acid, bilirubin, glucose**, cholesterol, calcium ion, iron ion. Genetic basis of **phenylketonuria, sickle cell anemia, gout.**

2) Biochemistry of some diseases: **Jaundice, Cholera.**

E. Molecular Biology:

(i) **DNA replication, transcription, structures of t-RNA** and **Translation, Genetic code, Mutation, DNA sequencing**, Northern blotting, **Southern blotting** and Western blotting.

(ii) **Restriction enzymes, Vectors, cDNA, Polymerase chain reaction (PCR),** Human Genome Project.

(iii) **Lac operon and arabinose operon.**

Short Notes on the important topics from the syllabus:

Physical Chemistry

Relative Atomic Mass (A_r)

- **Calculation:** A_r = Σ (isotope mass × % abundance) / 100
- **Example:** Chlorine has two main isotopes: Cl-35 (75%) and Cl-37 (25%).
  - A_r(Cl) = (35 × 75 + 37 × 25) / 100 = 35.5

Atomic Models (Historical Progression)

- **Dalton's Model (1803):** "Billiard Ball" model. Atoms are indivisible, solid spheres.
- **Thomson's Model (1897):** "Plum Pudding" model. A sphere of positive charge with negative electrons embedded in it.
- **Rutherford Model (1911): Nuclear Model.** From the gold foil experiment. A tiny, dense, positive nucleus surrounded by a cloud of negative electrons, mostly empty space.
- **Bohr Model (1913): Planetary Model.** Electrons orbit the nucleus in fixed, stable energy levels (shells). Explained atomic spectra.
- **Quantum Mechanical Model (Modern):** Electrons do not orbit in fixed paths. They exist in "orbitals" (3D regions of space) where there is a high probability of finding them. Defined by quantum numbers.

- **Summary of Key Relationships**

Concept	Symbol	Depends On	Key Idea
Atomic Number	**Z**	Number of **Protons**	Defines the element
Mass Number	**A**	Protons + **Neutrons**	Defines a specific isotope
Relative Atomic Mass	**A_r**	Weighted average of all isotopes	The "everyday" mass of an element
The Mole	**mol**	**Avogadro's Constant**	A unit for counting particles
Avogadro's Constant	**N_a**	6.022×10^{23}	The number of particles per mole

Law	Constant	Relationship	Formula
Boyle's Law	Temperature (T)	$P \propto \frac{1}{V}$	$P_1V_1 = P_2V_2$
Charles's Law	Pressure (P)	$V \propto T$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$
Gay-Lussac's Law	Volume (V)	$P \propto T$	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$
Avogadro's Law	P, T	$V \propto n$	$\frac{V_1}{n_1} = \frac{V_2}{n_2}$
Combined Gas Law	n constant	Varies	$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$
Ideal Gas Law	None	PV, n, T relationship	$PV = nRT$

The **van der Waals equation** is a modification of the **ideal gas law** that accounts for the non-ideal behavior of real gases. It was developed by Johannes Diderik van der Waals in 1873. The ideal gas law, PV=nRT, makes two faulty assumptions: that gas molecules are point particles with no volume and that there are no intermolecular forces between them. The van der Waals equation corrects for these assumptions by introducing two constants, **a** and **b**.

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

Components of the Equation

The equation includes two correction factors that adjust the ideal gas law to better reflect real gas behavior:

- **Pressure Correction:** The term (V2an2) is added to the observed pressure, P. This accounts for the **intermolecular attractive forces** between gas molecules. These forces reduce the number and force of collisions with the container walls, leading to a lower observed pressure than an ideal gas would have. The constant **a** is a measure of the strength of these attractive forces and is specific to each gas. A higher value of **a** indicates stronger intermolecular attractions.
- **Volume Correction:** The term (V-nb) adjusts the volume. The constant **b** represents the **excluded volume**—the volume actually occupied by the gas molecules themselves. Because gas molecules have a finite size, the volume available for them to move in is less than the total volume of the container. The constant **b** is a measure of the

effective size of the gas molecules. A higher value of **b** means the molecules are larger and occupy a greater volume.

Entropy (S) is a fundamental thermodynamic property that measures the degree of randomness, disorder, or energy dispersal within a system.

Key Concepts and Principles

- **Entropy and Spontaneity:** The **Second Law of Thermodynamics** is directly related to entropy. It states that for any spontaneous process, the total entropy of the universe (system + surroundings) must increase. This means that processes in nature tend to move toward a state of greater disorder and energy dispersal. While the entropy of a system can decrease, this is only possible if there is a larger increase in the entropy of the surroundings, ensuring the total change is positive.
- **States of Matter:** Entropy generally increases as a substance transitions from a more ordered state to a less ordered state.
    - **Solids:** Have the lowest entropy because their particles are in fixed positions, with very limited movement.
    - **Liquids:** Have higher entropy than solids because their particles can move past one another, allowing for more possible arrangements.
    - **Gases:** Have the highest entropy because their particles are widely dispersed and move randomly and chaotically, resulting in the greatest number of possible arrangements.
- **Temperature:** Increasing the temperature of a substance increases its entropy. As temperature rises, the kinetic energy of the particles increases, leading to more vigorous and random motion, which creates more microstates.

Calculating Entropy Change (ΔS)

The change in entropy (ΔS) for a process can be calculated in a few ways:

For a chemical reaction: The standard entropy change of a reaction ($\Delta S°_{rxn}$) can be calculated from the standard molar entropies ($S°$) of the products and reactants.

$$\Delta S°_{rxn} = \Sigma S°_{products} - \Sigma S°_{reactants}$$

Unlike standard enthalpies of formation, the standard molar entropy of an element in its standard state is not zero.

Osmosis is the spontaneous net movement of a **solvent** (usually water) across a **semipermeable membrane** from a region of lower solute concentration to a region of higher solute concentration. The membrane allows the solvent molecules to pass through but blocks the larger solute particles. This movement occurs to equalize the concentration of the solute on both sides of the membrane.

Features of Osmosis

- **Semipermeable membrane:** This is a crucial component. The membrane's pores are small enough to let solvent molecules (like water) pass, but not larger solute particles (like salt or sugar).
- **Concentration gradient:** The movement of the solvent is driven by the difference in solute concentration between the two solutions. The solvent moves "down its concentration gradient" from where it's more abundant (the dilute side) to where it's less abundant (the concentrated side).
- **Passive process:** Osmosis doesn't require energy input. It's a type of passive transport, meaning it's driven by the natural tendency of a system to move toward a state of equilibrium.

Osmotic pressure defined as the minimum pressure that must be applied to the solution side to prevent the net flow of solvent across the semipermeable membrane. Essentially, it's the pressure required to stop osmosis.

The osmotic pressure of a dilute solution can be calculated using the **van 't Hoff equation**, which is similar in form to the ideal gas law:

$$\Pi = iMRT$$

Where:

- Π is the osmotic pressure (in atmospheres).
- i is the **van 't Hoff factor**, which accounts for the number of particles a solute dissociates into in a solution (e.g., for sucrose, i=1; for NaCl, i=2).
- M is the **molar concentration** of the solute (moles/liter).
- R is the ideal gas constant (0.08206 L·atm/mol·K).
- T is the temperature in Kelvin.

ব্রনস্টেড-লাউরির তত্ত্বের সীমাবদ্ধতা :

১. এ তত্ত্বের সাহায্যে বিভিন্ন অধাতব অক্সাইড যেমন CO_2, SO_2, NO_2 এদের এসিডিয় ধর্ম ব্যাখ্যা করা যায় না। একইভাবে বিভিন্ন ধাতব অক্সাইড যেমন Na_2O, CaO, BaO এদের ক্ষারকীয় ধর্ম ব্যাখ্যা করা যায় না।

২. এ তত্ত্বের সাহায্যে BF_3, BCl_3, $AlCl_3$, $FeCl_3$ প্রভৃতি যৌগের এসিড ধর্ম ব্যাখ্যা করা যায় না।

৩. এ তত্ত্বের এসিড-ক্ষারের বিক্রিয়া প্রোটনের গ্রহণ ও বর্জনের মধ্যেই সীমাবদ্ধ। কিন্তু বাস্তবতা হলো অনেক এসিড–ক্ষারক বিক্রিয়া আছে যেখানে প্রোটনের আদান-প্রদান আদৌ ঘটে না। এ ধরনের বিক্রিয়া এ মতবাদের সাহায্যে ব্যাখ্যা করা যায় না। উদাহরণস্বরূপ : (i) $BF_3 + NH_3 = NH_3BF_3$; (ii) $Ag^+ + 2NH_3 = [Ag(NH_3)_2]^+$; (iii) $SiF_4 + 2F^- = [SiF_6]^{2-}$; (iv) $PCl_3 + 2Cl^- = [PCl_5]^{2-}$।

লুইস তত্ত্বের সীমাবদ্ধতা :

১. এ তত্ত্ব অনুযায়ী প্রোটনিক এসিড যেমন HCl, HNO_3, H_2SO_4 এদেরকে সরাসরি এসিড শ্রেণির অন্তর্ভুক্ত করা সম্ভব হয় না। যদিও বাস্তবে এরা এসিড। কারণ অবিয়োজিত এসিড অণুগুলো ক্ষারকের সাথে সন্নিবেশ বন্ধনে যুক্ত হতে পারে না।

২. এ তত্ত্বের সাহায্যে এসিড বা ক্ষারককে তাদের আপেক্ষিক তীব্রতা অনুযায়ী সাজানো যায় না। কারণ একই লুইস এসিড যখন ভিন্ন ভিন্ন লুইস ক্ষারকের সাথে যুক্ত হয় তখন ঐ এসিডের তীব্রতার মাত্রা ভিন্ন হয়ে থাকে। আবার একই লুইস ক্ষারক বিভিন্ন লুইস এসিডের সাথে বিক্রিয়া করলে ঐ ক্ষারকের তীব্রতা বিভিন্ন ক্ষেত্রে বিভিন্ন হয়।

Buffer System	Biological Role	Clinical Importance
Bicarbonate buffer	Maintains blood pH	Respiratory and metabolic acidosis/alkalosis
Phosphate buffer	Intracellular and kidney function	Urinary pH regulation
Protein buffer	Regulates blood pH (e.g., hemoglobin)	Oxygen transport and CO_2 buffering

Condition	Cause	pH Change
Respiratory Acidosis	Hypoventilation → ↑ CO_2	↓ Blood pH
Respiratory Alkalosis	Hyperventilation → ↓ CO_2	↑ Blood pH
Metabolic Acidosis	Lactic acid buildup, kidney failure	↓ Blood pH
Metabolic Alkalosis	Vomiting, excess bicarbonate	↑ Blood pH

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Buffering capacity is a measure of a buffer solution's ability to resist a change in pH when a strong acid or strong base is added. It is defined as the amount of strong acid or base (in moles) required to change the pH of one liter of the buffer solution by one pH unit.

A buffer has its maximum capacity when the concentrations of the weak acid and its conjugate base are equal, meaning pH=pKa.

Buffering capacity increases with higher concentrations of the buffer components.

The **Beer-Lambert Law** states that the absorbance of a solution is directly proportional to the concentration of the solute and the path length of the light through the solution.

- The law is expressed by the equation:

$$A=\epsilon bc$$

- A = Absorbance (a unitless measure of how much light is absorbed)
- ϵ (Epsilon) = Molar absorptivity (L·mol-1·cm-1), a constant that is unique to the substance at a specific wavelength.
- b = Path length of the light through the solution (cm).
- c = Concentration of the absorbing substance (mol/L).

Standard Free Energy Change (ΔG°)

Definition:
The **Standard Free Energy Change (ΔG°)** is the change in free energy for a reaction when all reactants and products are in their **standard states** (typically 1 M concentration for solutions, 1 atm pressure for gases, and a specified temperature, usually 25 °C or 298 K).

Key Equation:
It is most commonly calculated using the equation:
$\Delta G^\circ = \Delta H^\circ - T\Delta S^\circ$
where:

- ΔH° is the **standard enthalpy change**.
- T is the **temperature in Kelvin**.
- ΔS° is the **standard entropy change**.

It is also related to the **equilibrium constant (K)** by:

$\Delta G° = -RT \ln K$

where R is the universal gas constant (8.314 J/mol·K).

Interpretation and Significance:

- **$\Delta G° < 0$ (Negative):** The reaction is **spontaneous** (thermodynamically favorable) under standard conditions. The products are favored at equilibrium ($K > 1$).
- **$\Delta G° > 0$ (Positive):** The reaction is **non-spontaneous** under standard conditions. The reactants are favored at equilibrium ($K < 1$).
- **$\Delta G° = 0$:** The reaction is at **equilibrium** under standard conditions ($K = 1$).

Most encountered reaction from organic chemistry:

1. **Free Radical Substitution of Alkanes**
    - **Example:** $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$ (in UV light)
    - *Mechanism:* Free radical chain reaction.
2. **Nucleophilic Substitution on Haloalkanes**
    - **Example (with KCN):** $CH_3\text{-}CH_2\text{-}Br + KCN \rightarrow CH_3\text{-}CH_2\text{-}CN + KBr$
    - *Mechanism:* SN^2 or SN^1.
3. **Electrophilic Aromatic Substitution (Benzene)**
    - **Halogenation:** $C_6H_6 + Cl_2 \rightarrow C_6H_5Cl + HCl$ (with $FeCl_3$ catalyst)
    - **Nitration:** $C_6H_6 + HNO_3 \rightarrow C_6H_5NO_2 + H_2O$ (with conc. H_2SO_4)
    - **Sulfonation:** $C_6H_6 + H_2SO_4 \rightarrow C_6H_5SO_3H + H_2O$
    - **Friedel-Crafts Alkylation:** $C_6H_6 + CH_3Cl \rightarrow C_6H_5CH_3 + HCl$ (with $AlCl_3$)
    - **Friedel-Crafts Acylation:** $C_6H_6 + CH_3COCl \rightarrow C_6H_5COCH_3 + HCl$ (with $AlCl_3$)
4. **Addition of Hydrogen (Hydrogenation/Catalytic Reduction)**
    - **Example:** $CH_2{=}CH_2 + H_2 \rightarrow CH_3\text{-}CH_3$ (with Ni/Pt/Pd catalyst)
5. **Addition of Halogens (Halogenation)**
    - **Example (Test for unsaturation):** $CH_2{=}CH_2 + Br_2$ (aq) $\rightarrow CH_2Br\text{-}CH_2Br$ (Decolorizes bromine water)
6. **Addition of Hydrogen Halides (Markovnikov's Rule)**
    - **Example:** $CH_3\text{-}CH{=}CH_2 + HBr \rightarrow CH_3\text{-}CHBr\text{-}CH_3$ (2-Bromopropane)

7. **Addition of Water (Hydration)**
    - **Example (of alkyne):** $CH \equiv CH + H_2O \rightarrow [CH_2=CH-OH] \rightarrow CH_3CHO$ (Acetaldehyde) (with Hg^{2+}/H^+)
8. **Anti-Markovnikov Addition (Peroxide Effect)**
    - **Example:** $CH_3-CH=CH_2 + HBr \rightarrow CH_3-CH_2-CH_2Br$ (in presence of peroxides)
9. **Dehydrohalogenation of Haloalkanes**
    - **Example:** $CH_3-CH_2-Br + KOH$ (alc.) $\rightarrow CH_2=CH_2 + KBr + H_2O$
10. **Dehydration of Alcohols**
    - **Example:** $CH_3-CH_2-OH \rightarrow CH_2=CH_2 + H_2O$ (with conc. H_2SO_4 at 170°C)
11. **Oxidation of Primary Alcohols**
    - **To Aldehyde:** $CH_3CH_2OH + [O] \rightarrow CH_3CHO + H_2O$ (with Pyridinium chlorochromate (PCC) or dist. $KMnO_4$)
    - **To Carboxylic Acid:** $CH_3CH_2OH + 2[O] \rightarrow CH_3COOH + H_2O$ (with $K_2Cr_2O_7/H^+$)
12. **Oxidation of Secondary Alcohols**
    - **To Ketone:** $(CH_3)_2CH-OH + [O] \rightarrow (CH_3)_2C=O + H_2O$ (with $K_2Cr_2O_7/H^+$)
13. **Oxidation of Alkenes (with Ozonolysis)**
    - **Example:** $CH_2=CH_2 + O_3 \rightarrow$ (in Zn/H_2O) $\rightarrow HCHO$ (Formaldehyde)
14. **Oxidation of Alkynes (with Ozonolysis)**
    - **Example:** $CH_3-C \equiv C-CH_3 + O_3 \rightarrow$ (in H_2O) $\rightarrow 2\ CH_3COOH$ (Acetic acid)
15. **Reduction of Aldehydes/Ketones**
    - **To Alcohols:** $CH_3CHO + 2[H] \rightarrow CH_3CH_2OH$ (with $NaBH_4$ or $LiAlH_4$)
16. **Reduction of Nitriles**
    - **To Primary Amines:** $CH_3CH_2-CN + 4[H] \rightarrow CH_3CH_2-CH_2-NH_2$ (with $LiAlH_4$ or catalytic hydrogenation)
17. **Reduction of Nitrobenzene**
    - **To Aniline:** $C_6H_5-NO_2 + 3Sn + 6HCl \rightarrow C_6H_5-NH_2 + 3SnCl_2 + 2H_2O$
18. **Carbylamine Reaction (Isocyanide Test)**
    - **Example:** $C_2H_5NH_2 + CHCl_3 + 3KOH \rightarrow C_2H_5NC + 3KCl + 3H_2O$ (Foul smell)
19. **Reimer-Tiemann Reaction**
    - **Example:** $C_6H_5OH + CHCl_3 + NaOH \rightarrow$ o-Hydroxybenzaldehyde
20. **Aldol Condensation**
    - **Example:** $2CH_3CHO \rightarrow$ (with dil. NaOH) $\rightarrow CH_3CH(OH)CH_2CHO$ (3-Hydroxybutanal)
21. **Cannizzaro Reaction**
    - **Example (of Formaldehyde):** $2HCHO + NaOH \rightarrow CH_3OH + HCOONa$

22. **Esterification**
    - **Example:** $CH_3COOH + CH_3CH_2OH \rightleftharpoons CH_3COOCH_2CH_3 + H_2O$ (with conc. H_2SO_4)
23. **Acidic Hydrolysis of Esters (Saponification)**
    - **Example:** $CH_3COOC_2H_5 + H_2O \rightarrow CH_3COOH + C_2H_5OH$ (with dil. acid)
24. **Basic Hydrolysis of Esters (Saponification)**
    - **Example:** $CH_3COOC_2H_5 + NaOH \rightarrow CH_3COONa + C_2H_5OH$

Biomolecules

Carbohydrates (or saccharides) are primarily defined as **polyhydroxy aldehydes or ketones** or substances that hydrolyze to yield them. They are primarily composed of carbon, hydrogen, and oxygen $(C_n(H_2O)_n)$.

They are classified based on two main criteria:

1. **Based on Hydrolysis**
2. **Based on the Functional Group**

1. Classification Based on Hydrolysis

(This classification is based on the number of sugar units produced upon hydrolysis.)

Category	Number of Monomer Units	Description & Examples
Monosaccharides	One (Cannot be hydrolyzed further)	**Simple sugars.** They are the simplest building blocks. • **Examples:** - **Glucose** (Aldose) - **Fructose** (Ketose) - **Galactose** (Aldose)
Oligosaccharides	2 to 10	Yield a few monosaccharide units on hydrolysis. • **Disaccharides** (2 units): - **Sucrose** (Glucose + Fructose) - **Lactose** (Glucose + Galactose)

Category	Number of Monomer Units	Description & Examples
		- **Maltose** (Glucose + Glucose) • **Trisaccharides** (3 units): e.g., Raffinose
Polysaccharides	Many (n)	**Polymers** of monosaccharides. They are not sweet and are non-crystalline. • **Examples:** - **Starch** (Polymer of glucose - plant storage) - **Cellulose** (Polymer of glucose - plant structural) - **Glycogen** (Polymer of glucose - animal storage) - **Inulin** (Polymer of fructose)

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2. Classification Based on Functional Group

(This classification is based on the type of carbonyl group they contain.)

Category	Functional Group	Description & Examples
Aldoses	Aldehyde (-CHO)	Contain an aldehyde group. • **Examples:** - **Glucose** - **Galactose** - **Ribose**
Ketoses	Ketone (>C=O)	Contain a ketone group. • **Examples:**

Category	Functional Group	Description & Examples
		- **Fructose** - **Ribulose**

Additional Common Classifications

A. Based on Number of Carbon Atoms:

- **Trioses** (3C): e.g., Glyceraldehyde
- **Tetroses** (4C): e.g., Erythrose
- **Pentoses** (5C): e.g., **Ribose**, Deoxyribose (in nucleic acids)
- **Hexoses** (6C): e.g., **Glucose**, Fructose, Galactose

B. Reducing vs. Non-Reducing Sugars:

- **Reducing Sugars:** Have a free aldehyde or ketone group that can reduce Fehling's or Tollen's reagent.
  - *Examples:* All monosaccharides, Maltose, Lactose.
- **Non-Reducing Sugars:** No free carbonyl group; it is involved in glycosidic bonding.
  - *Example:* **Sucrose**.

Table 2.2 Monosaccharides and disaccharides of biological importance

Monosaccharides	*Occurrence*	*Biochemical importance*
Trioses		
Glyceraldehyde	Found in cells as phosphate	Glyceraldehyde 3-phosphate is an intermediate in glycolysis
Dihydroxyacetone	Found in cells as phosphate	Its 1-phosphate is an intermediate in glycolysis
Tetroses		
D-Erythrose	Widespread	Its 4-phosphate is an intermediate in carbohydrate metabolism
Pentoses		
D-Ribose	Widespread as a constituent of RNA and nucleotides	For the structure of RNA and nucleotide coenzymes (ATP, NAD^+, $NADP^+$)
D-Deoxyribose	As a constituent of DNA	For the structure of DNA
D-Ribulose	Produced during metabolism	It is an important metabolite in hexose monophosphate shunt
D-Xylose	As a constituent of glycoproteins and gums	Involved in the function of glycoproteins
L-Xylulose	As an intermediate in uronic acid pathway	Excreted in urine in essential pentosuria
D-Lyxose	Heart muscle	As a constituent of lyxoflavin of heart muscle

Hexoses		
D-Glucose	As a constituent of polysaccharides (starch, glycogen, cellulose) and disaccharides (maltose, lactose, sucrose). Also found in fruits	The 'sugar fuel' of life; excreted in urine in diabetes. Structural unit of cellulose in plants
D-Galactose	As a constituent of lactose (milk sugar)	Converted to glucose, failure leads to galactosemia
D-Mannose	Found in plant polysaccharides and animal glycoproteins	For the structure of polysaccharides
D-Fructose	Fruits and honey, as a constituent of sucrose and inulin	Its phosphates are intermediates of glycolysis
Heptoses		
D-Sedoheptulose	Found in plants	Its 7-phosphate is an intermediate in hexose monophosphate shunt, and in photosynthesis
Disaccharides	*Occurrence*	*Biochemical importance*
Sucrose	As a constituent of cane sugar and beet sugar, pineapple	Most commonly used table sugar supplying calories
Lactose	Milk sugar	Exclusive carbohydrate source to breast fed infants. Lactase deficiency (lactose intolerance) leads to diarrhea and flatulence
Maltose	Product of starch hydrolysis, occurs in germinating seeds	An important intermediate in the digestion of starch

a. Carbohydrates are the poly-hydroxyl-aldehydes or ketones, or compounds which produce them on hydrolysis. The term sugar is applied to carbohydrates soluble in water and sweet to taste. Carbohydrates are the major dietary energy sources, besides their involvement in cell structure and various other functions.

b. Carbohydrates are broadly classified into 3 groups—monosaccharides, oligosaccharides and polysaccharides. The monosaccharides are further divided into different categories based on the presence of functional groups (aldoses or ketoses) and the number of carbon atoms (trioses, tetroses, pentoses, hexoses and heptoses).

c. Glyceraldehyde (triose) is the simplest carbohydrate and is chosen as a reference to write the configuration of all other monosaccharides (D- and L- forms). If two monosaccharides differ in their structure around a single carbon atom, they are known as epimers. Glucose and galactose are C4 – epimers.

d. D-Glucose is the most important naturally occurring aldose/monosaccharide. Glucose exists as anomers with different optical rotations

e. Monosaccharides participate in several reactions. These include oxidation, reduction, dehydration, osazone formation etc. Formation of esters and glycosides.

f. Among the oligosaccharides, disaccharides are the most common. These include the reducing disaccharides namely lactose (milk sugar) and maltose (malt sugar) and the non-reducing sucrose (cane sugar).
g. Polysaccharides are the polymers of monosaccharides or their derivatives, held together by glycosidic bonds. Homopolysaccharides are composed of a single monosaccharide (e.g., starch, glycogen, cellulose, insulin). Heteropolysaccharides contain a mixture of few monosaccharides or their derivatives (e.g., mucopolysaccharides).
h. Starch and glycogen are the carbohydrate reserves of plants and animals respectively. Cellulose, exclusively found in plants, is the structural constituent. Inulin is utilized to assess kidney function by measuring glomerular filtration rate (GFR).
i. Mucopolysaccharides (glycosaminoglycans) are the essential components of tissue structure. They provide the matrix or ground substance of extracellular tissue spaces in which collagen and elastin fibers are embedded. Hyaluronic acid, chondroitin 4-sulfate, heparin, are among the important glycosaminoglycans.
j. Glycoproteins are a group of biochemically important compounds with a variable composition of carbohydrate (1-90%), covalently bound to protein. Several enzymes, hormones, structural proteins and cellular receptors are in fact glycoproteins.

Lipids

a) Lipids are the organic substances relatively insoluble in water, soluble in organic solvents (alcohol, ether), actually or potentially related to fatty acids and are utilized by the body.
b) Lipids are classified into simple (fats and oils), complex (phospholipids, glycolipids), derived (fatty acids, steriod hormones) and miscellaneous (carotenoids).
c) Fatty acids are the major constituents of various lipids. Saturated and unsaturated fatty acids almost equally occur in natural lipids. The polyunsaturated fatty acids (PUFA) namely linoleic acid and linolenic acid are the essential fatty acids that need to be supplied in the diet.
d) Triacylglycerols (simply fats) are the esters of glycerol with fatty acids. They are found in adipose tissue and primarily function as fuel reserve of animals. Several tests (iodine number, RM number) are employed in the laboratory to test the purity of fats and oils.
e) Phospholipids are complex lipids containing phosphoric acid. Glycerophospholipids contain glycerol as the alcohol and these include lecithin, cephalin, phosphatidylinositol, plasmalogen and cardiolipin.
f) Sphingophospholipids (sphingomyelins) contain sphingosine as the alcohol in place of glycerol (in glycerophospholipids). Phospholipids are the major constituents of plasma membranes.

g) Cerebrosides are the simplest form of glycolipids which occur in the membranes of nervous tissue. Gangliosides are predominantly found in the ganglions. They contain one or more molecules of N-acetylneuraminic acid (NANA).

h) Steroids contain the ring cyclopentanoperhydrophenanthrene. The steroids of biological importance include cholesterol, bile acids, vitamin D, sex hormones and cortical hormones. A steroid containing one or more hydroxyl groups is known as sterol.

i) Cholesterol is the most abundant animal sterol. It contains one hydroxyl group (at C3), a double bond (C5–C6) and an eight carbon side chain attached to C17. Cholesterol is a constituent of membrane structure and is involved in the synthesis of bile acids, hormones (sex and cortical) and vitamin D.

j) The lipids that possess both hydrophobic (non -polar) and hydrophilic (polar) groups are known as amphipathic. These include fatty acids, phospholipids, sphingolipids and bile salts. Amphipathic lipids are important constituents in the bilayers of the biological membranes.

Proteins

a. Proteins are nitrogen containing, most abundant organic macromolecules widely distributed in animals and plants. They perform structural and dynamic functions in the organisms.

b. Proteins are polymers composed of L-amino acids. They are 20 in number and classified into different groups based on their structure, chemical nature, nutritional requirement and metabolic fate. Selenocysteine has been recently identified as the 21st amino acid, and is found in certain proteins.

c. Amino acids possess two functional groups namely carboxyl (-COOH) and amino (-NH2). In the physiological system, they exist as dipolar ions commonly referred to as zwitterions.

d. Besides the 20 standard amino acids present in proteins, there are several non-standard amino acids. These include the amino acid derivatives found in proteins (e.g. hydroxyproline, hydroxylysine) and, non-protein amino acids (e.g. ornithine, citrulline).

e. The structure of protein is divided into four levels of organization. The primary structure represents the linear sequence of amino acids. The twisting and spatial arrangement of polypeptide chain is the secondary structure. Tertiary structure constitutes the three dimensional structure of a functional protein. The assembly of similar or dissimilar polypeptide subunits comprises quaternary structure.

f. The determination of primary structure of a protein involves the knowledge of quality, quantity and the sequence of amino acids in the polypeptide. Chemical and enzymatic methods are employed for the determination of primary structure.

g. The secondary structure of protein mainly consists of alpha helix and/or beta sheet. Alpha-Helix is stabilized by extensive hydrogen bonding. Beta-Pleated sheet is composed of two or more segments of fully extended polypeptide chains.
h. The tertiary and quaternary structures of protein are stabilized by non-covalent bonds such as hydrogen bonds, hydrophobic interactions, ionic bonds etc.
i. Proteins are classified into three major groups. Simple proteins contain only amino acid residues (e.g. albumin). Conjugated proteins contain a non-protein moiety known as prosthetic group, besides the amino acids (e.g. glycoproteins). Derived proteins are obtained by degradation of simple or conjugated proteins.
j. In addition to proteins, several peptides perform biologically important functions. These include glutathione, oxytocin and vasopressin.

Nucleic acids

a. DNA is the chemical basis of heredity organized into genes, the basic units of genetic information.
b. RNAs (mRNA, tRNA and rRNA) are produced by DNA which in turn carry out protein synthesis.
c. Nucleic acids are the polymers of nucleotides (polynucleotides) held by 3' and 5' phosphodiester bridges. A nucleotide essentially consists of base + sugar (nucleoside) and phosphate.
d. Besides being the constituents of nucleic acid structure, nucleotides perform a wide variety of cellular functions (e.g. energy carriers, metabolic regulators, second messengers etc.)
e. Both DNA and RNA contain the purines-adenine (A) and guanine (G) and the pyrimidinecytosine (C). The second pyrimidine is thymine (T) in DNA while it is uracil (U) in RNA. The pentose sugar, D-deoxyribose is found in DNA while it is D-ribose in RNA.
f. The structure of DNA is a double helix (Watson-Crick model) composed of two antiparallel strands of polydeoxynucleotides twisted around each other. The strands are held together by 2 or 3 hydrogen bonds formed between the bases i.e. A = T; GC. DNA structure satisfies Chargaff's rule that the content of A is equal to T, and that of G equal to C.
g. Besides the double helical structure, DNA also exists in certain unusual structures — bent DNA, triple-strand DNA, four-strand DNA.
h. RNA is usually a single stranded polyribonucleotide. mRNA is capped at 5' terminal end by 7-methylGTP while at the 3'-terminal end, it contains a poly A tail. mRNA specifies the sequence of amino acids in protein synthesis.
i. The structure of tRNA resembles that of a clover leaf with four arms (acceptor, anticodon, D-, and T□C) held by complementary base pairs. tRNA delivers amino acids for protein synthesis.

j. Certain RNAs that can function as enzymes are termed as ribozymes. Ribozymes were probably functioning as catalysts before the occurrence of protein enzymes during evolution.

Enzyme

a. Enzymes are the protein biocatalysts synthesized by the living cells. They are classified into six major classes—oxidoreductases, transferases, hydrolases, lyases, isomerases and ligases.
b. An enzyme is specific in its action, possessing active site, where the substrate binds to form enzyme-substrate complex, before the product is formed.
c. Factors like concentration of enzyme, substrate, temperature, pH etc. influence enzyme activity. The substrate concentration to produce half-maximal velocity is known as Michaelis constant (Km value).
d. Enzyme activities are inhibited by reversible (competitive, and non-competitive), irreversible and allosteric manner.
e. Many enzymes require certain non-protein substances called cofactors (coenzymes) for their action. Most of the coenzymes are derivatives of B-complex vitamins (e.g. NAD+, FAD, TPP etc.)
f. The mechanism of enzyme action is explained by lock and key model (of Fischer), more recently induced fit model (of Koshland) and substrate strain theory.
g. The enzymes enhance the rate of reaction through acid-base catalysis, covalent catalysis and/or proximity catalysis.
h. In the living system, there is a constant regulation of enzyme levels, brought about by allosteric mechanism, activation of proenzymes, synthesis and degradation of enzymes etc.
i. Estimation of serum enzymes is of great help in the diagnosis of several diseases. Serum amylase and lipase are increased in acute pancreatitis; alanine transaminase in hepatitis; aspartate transaminase, lactate dehydrogenase (LDH) and creatine phosphokinase (CPK) in myocardial infarction; alkaline phosphatase in rickets and hyperparathyroidism; acid phosphatase in prostatic carcinoma; □-glutamyl transpeptidase in alcoholism.
j. Isoenzymes are the multiple forms of an enzyme catalysing the same reaction which however, differ in their physical and chemical properties. LDH has five isoenzymes while CPK has three. LDH1 and CPK2 are very important in the diagnosis of MI.

Vitamin

a. Vitamins are accessory food factors required in the diet. They are classified as fat soluble (A, D, E and K) and water soluble (B-complex and C).
b. Vitamin A is involved in vision, proper growth, differentiation and maintenance of epithelial cells. Its deficiency results in night blindness.

c. The active form of vitamin D is calcitriol which functions like a steroid hormone and regulates plasma levels of calcium and phosphate. Vitamin D deficiency leads to rickets in children and osteomalacia in adults.
d. Vitamin E is a natural antioxidant necessary for normal reproduction in many animals.
e. Vitamin K has a specific coenzyme function. It catalyses the carboxylation of glutamic acid residues in blood clotting factors (II, VII, IX and X) and converts them to active form.
f. Thiamine (B1), as a cocarboxylase (TPP) is involved in energy releasing reactions. Its
b) deficiency leads to beri-beri.
a. The coenzymes of riboflavin (FAD and FMN) and niacin (NAD+ and NADP+) take part in a variety of oxidation-reduction reactions connected with energy generation. Riboflavin deficiency results in cheilosis and glossitis whereas niacin deficiency leads to pellagra.
b. Pyridoxal phosphate (PLP), the coenzyme of vitamin B6, is mostly associated with amino acid metabolism. PLP participates in transamination, decarboxylation, deamination and condensation reactions.
c. Biotin (anti-egg white injury factor) participates as a coenzyme in carboxylation reactions of gluconeogenesis, fatty acid synthesis etc.
d. Coenzyme A (of pantothenic acid) is involved in the metabolism of carbohydrates, lipids and amino acids, and their integration.
e. Tetrahydrofolate (THF), the coenzyme of folic acid participates in the transfer of one carbon units (formyl, methyl etc.) in amino acid and nucleotide metabolism. Megaloblastic anemia is caused by folic acid deficiency.
f. Vitamin B12 has two coenzymes, deoxyadenosylcobalamin and methylcobalamin. B12 deficiency results in pernicious anemia.
g. Vitamin C (ascorbic acid) is involved in the hydroxylation of proline and lysine in the formation of collagen. Scurvy is caused by ascorbic acid deficiency. Therapeutic use of megadoses of vitamin C, to cure everything from common cold to cancer, has become controversial.
h. Certain vitamin like compounds (choline, inositol, PABA, lipoic acid) participate in many biochemical reactions.

Metabolism

Carbohydrate Metabolism

a. Carbohydrates are the major source of energy for the living cells. Glucose (normal fasting blood level 70-100 mg/dl) is the central molecule in carbohydrate metabolism, actively participating in a number of metabolic pathways—glycolysis, gluconeogenesis, glycogenesis, glycogenolysis, hexose monophosphate shunt, uronic acid pathway etc.

b. Glucose is oxidized in glycolysis, either in anaerobic (2 ATP formed) or aerobic (8 ATP formed) conditions, resulting in the formation of 2 moles of lactate or pyruvate, respectively.
c. Acetyl CoA is produced from pyruvate which is completely oxidized in citric acid cycle, the final common oxidative pathway for all foodstuffs. The complete oxidation of one mole of glucose generates 38 ATP.
d. Gluconeogenesis is the synthesis of glucose from noncarbohydrate precursors like amino acids (except leucine and lysine), lactate, glycerol, propionate etc. The reversal of glycolysis with alternate arrangements made at three irreversible reactions of glycolysis constitutes gluconeogenesis.
e. Glycogen is the storage form of glucose. The degradation of glycogen (glycogenolysis) in muscle meets the immediate fuel requirements, whereas the liver glycogen maintains the blood glucose level. Enzyme defects in synthesis or degradation of glycogen lead to storage disorders. von Gierke's disease (Type I) is due to the defect in the enzyme glucose 6-phosphatase.
f. Hexose monophosphate shunt (HMP shunt) is the direct oxidative pathway of glucose. HMP shunt assumes significance since it generates NADPH and pentoses, respectively required for the synthesis of lipids and nucleic acids.
g. Glucuronate—involved in the conjugation of bilirubin, steroid hormones and detoxification of drugs—is synthesized in uronic acid pathway. Due to a single enzyme defect (gulonolactone oxidase) in this pathway, man cannot synthesize ascorbic acid (vitamin C) whereas some animals can.
h. Galactosemia is mostly due to the defect in the enzyme galactose 1-phosphate uridyltransferase. This results in the diversion of galactose to produce galactitol which has been implicated in the development of cataract.
i. Glucose can be converted to fructose via sorbitol pathway. In prolonged hyperglycemia (uncontrolled diabetes), sorbitol accumulates in the tissues, resulting in cataract, nephropathy, peripheral neuropathy etc.
j. Amino sugars (glucosamine, galactosamine, mannosamine etc.), synthesized from fructose 6-phosphate are essential components of glycosaminoglycans, glycolipids and glycoproteins.

Lipid Metabolism

a. Triacylglycerols (TG) are the highly concentrated form of energy, stored in adipose tissue.Hormone-sensitive lipase hydrolyses TG to free fatty acids which are transported as albumin-FFA complexes.

b. Fatty acids are activated (acyl CoA) and transported by carnitine to mitchondria where they get oxidized (mostly by Beta-oxidation) to liberate energy. Complete oxidation of one mole palmitate liberates 129 ATP.
c. Excessive utilization of fatty acids occurs in uncontrolled diabetes mellitus and starvation. This results in the overproduction of ketone bodies (in liver), namely acetone, acetoacetic acid and Beta-hydroxy butyric acid. The last two ketone bodies serveas energy source for peripheral tissues.
d. Fatty acid biosynthesis occurs from acetyl CoA in the cytosol through the involvement of a multienzyme complex associated with acyl carrier protein (ACP). The reducing equivalents (NADPH + H+) are supplied mostly by HMP shunt.
e. Synthesis of triacylglycerols and phospholipids (PL) occurs from glycerol 3-phosphateand dihydroxyacetone phosphate with the addition of acyl CoA, and activated nitrogenous bases (for PL).
f. Cholesterol is synthesized from acetyl CoA in a series of reactions involving HMG CoA, mevalonate, isoprenoid units and squalene as the intermediates. Cholesterol serves as a precursor for bile acids, steroid hormones and vitamin D.
g. Lipoproteins are the transport vehicles for lipids in the plasma. Lipoprotein disorders are associated with abnormalities in their plasma levels. Elevation in LDL and VLDL— in association with cholesterol and TG—poses a serious health problem with increased risk of atherosclerosis and CHD.
h. Excessive accumulation of triacylglycerols in liver causes fatty liver, which may be due to increased production of TG or impairment in lipoprotein (VLDL) synthesis. The latter is mostly associated with the deficiency of certain substances called lipotropic factors (e.g. choline, betaine, methionine etc.)
i. Obesity is an abnormal increase in body weight (with more than 25% due to fat). Among the many causative factors of obesity, lack of active brown adipose tissues (which burn fat and liberate heat) in these individuals is gaining importance.
j. Atherosclerosis is a complex disease characterized by thickening of arteries due to the accumulation of lipids. Atherosclerosis and CHD are directly correlated with LDL and inversely with HDL of plasma.

Amino Acid Metabolism

a. The body proteins are in a dynamic state (degradation and synthesis) and there is an active amino acid pool (100 g) maintained for this purpose.
b. The amino acids undergo transamination and deamination to liberate ammonia for the synthesis of urea, the end product of protein metabolism.

c. Besides being present as structural components of proteins, amino acids participate in the formation of several biologically important compounds.
d. Glycine is involved in the synthesis of creatine, heme, purines, glutathione etc.
e. Phenylalanine is hydroxylated to tyrosine, which is a precursor for the production of skin pigment (melanin), catecholamines (dopamine, epinephrine and norepinephrine) and thyroid hormones (T3 and T4).
f. Tryptophan is converted to NAD+ and NADP+, the coenzymes of niacin, serotonin (a neurotransmitter) and melatonin.
g. The active methionine (SAM) is a donor of methyl group (transmethylation) for the synthesis of many biological compounds (epinephrine, choline, methylcytosine etc.).
h. Many amino acids contribute to one-carbon fragments (formyl, formimino, methylene etc.) for participation in one-carbon metabolism—which is mostly under the control of tetrahydrofolate.
i. The carbon skeleton of amino acids is involved either in the synthesis of glucose (glycogenic) or fat (ketogenic), or both-glucose and fat.
j. Many inborn errors (mostly due to enzyme defects) in amino acid metabolism have been identified. These include phenylketonuria (defect-phenylalanine hydroxylase), albinism (defect-tyrosinase), maple syrup urine disease etc.

Blood: Composition and Functions

Definition: Blood is a specialized bodily fluid (a connective tissue) that transports essential substances throughout the body.

A. Composition of Blood:

Blood is composed of two main components:

- **Plasma (55%):** The straw-colored liquid matrix.
  - **Water (90-92%):** Solvent for transport.
  - **Proteins (7-8%):** Albumin (osmotic pressure), Fibrinogen (clotting), Globulins (immunity, transport).
  - **Other Solutes (1-2%):** Nutrients (glucose, amino acids), Gases (O_2, CO_2), Electrolytes (Na^+, K^+, Ca^{2+}), Hormones, Waste products (urea).
- **Formed Elements (45%):** The cellular component.
  - **Erythrocytes (Red Blood Cells - RBCs)**
  - **Leukocytes (White Blood Cells - WBCs)**
  - **Thrombocytes (Platelets)**

B. Functions of Blood:

1. **Transport:** Carries O_2 from lungs to tissues, CO_2 from tissues to lungs, nutrients from the gut to cells, hormones from glands to target organs, and waste to kidneys/liver.

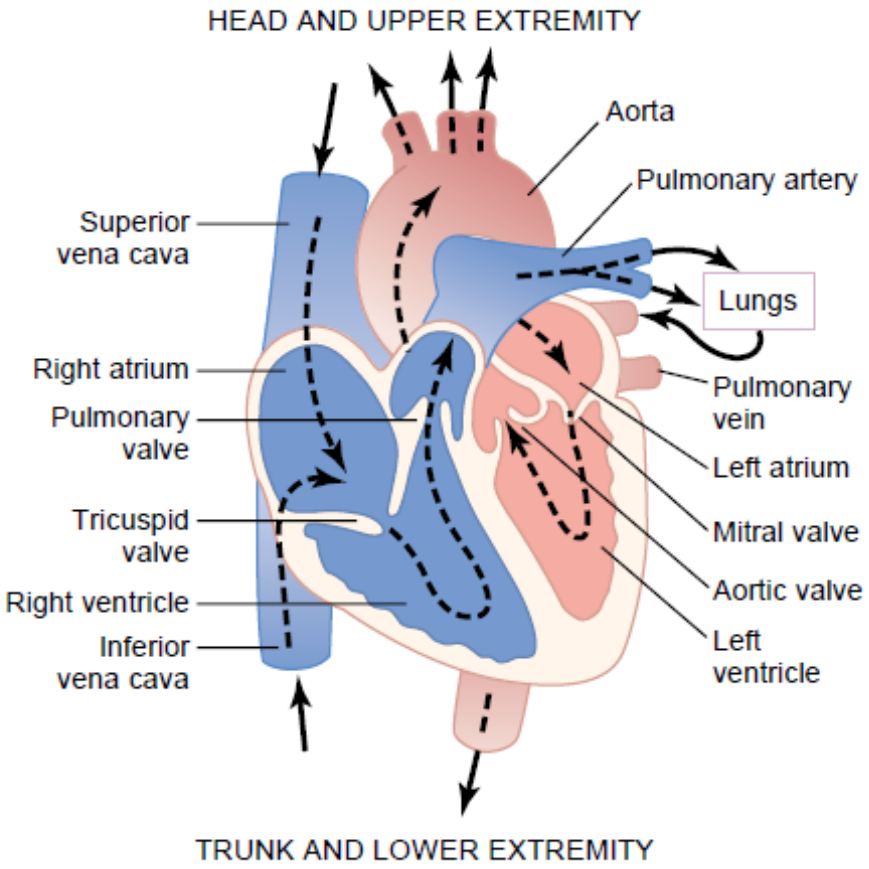
2. **Regulation:** Regulates body temperature, pH (buffers), and water balance.
3. **Protection:** WBCs fight infections (immunity). Platelets and clotting factors prevent blood loss (hemostasis).

3. Blood Grouping (ABO and Rh System)

- **Basis:** Classification is based on the presence or absence of inherited **antigens** (agglutinogens) on the surface of RBCs.
- **ABO Groups:**
  - **Group A:** Has A antigen, produces anti-B antibodies.
  - **Group B:** Has B antigen, produces anti-A antibodies.
  - **Group AB:** Has both A & B antigens, produces **no antibodies** (Universal Recipient).
  - **Group O:** Has no antigens, produces both anti-A & anti-B antibodies (Universal Donor).
- **Rh Factor:**
  - **Rh+:** Has the Rh (D) antigen on RBCs.
  - **Rh-:** Lacks the Rh antigen. Produces anti-Rh antibodies only upon exposure to Rh+ blood.
- **Significance:** Crucial for safe blood transfusions and preventing **erythroblastosis fetalis** (hemolytic disease of the newborn) in Rh- mothers with an Rh+ baby.

Physiology

Heart Structure



The heart is a four-chambered muscular pump.

- **Chambers:**
  - **Atria (2):** Upper, thin-walled receiving chambers. (**Right atrium** receives deoxygenated blood from body; **Left atrium** receives oxygenated blood from lungs).
  - **Ventricles (2):** Lower, thick-walled pumping chambers. (**Right ventricle** pumps blood to lungs; **Left ventricle** has the thickest wall to pump blood to the entire body).
- **Valves:** Ensure one-way blood flow.
  - **Atrioventricular (AV) Valves:** Tricuspid (right), Bicuspid/Mitral (left).
  - **Semilunar Valves:** Pulmonary (right), Aortic (left).
- **Major Blood Vessels:**
  - **Vena Cava:** Brings deoxygenated blood to RA.
  - **Pulmonary Artery:** Takes blood from RV to lungs.
  - **Pulmonary Veins:** Bring oxygenated blood from lungs to LA.
  - **Aorta:** Takes oxygenated blood from LV to the body.
- **Myocardium:** The cardiac muscle tissue itself. Requires a constant supply of oxygen provided by the **coronary arteries**.

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5. Coronary Heart Disease (CHD)

Definition: A group of diseases caused by the reduced supply of oxygenated blood to the heart muscle (myocardium), primarily due to the narrowing or blockage of the **coronary arteries**.

- **Main Cause: Atherosclerosis**
  - Buildup of fatty deposits (**plaques**), cholesterol, and cellular waste on the inner walls of coronary arteries.
  - This causes the arteries to harden and narrow, restricting blood flow.
- **Major Consequences:**

1. **Angina Pectoris:** Severe, constricting chest pain or pressure due to temporary oxygen deficiency. Often triggered by exertion or stress.
2. **Myocardial Infarction (Heart Attack):** Occurs when a coronary artery is completely blocked (e.g., by a blood clot forming on a ruptured plaque). This causes **death (necrosis) of a part of the heart muscle** due to prolonged oxygen deprivation. A medical emergency.
3. **Heart Failure:** The heart becomes too weak to pump blood efficiently, which can be a long-term consequence of CHD.

- **Risk Factors:** Smoking, high blood pressure, high cholesterol, diabetes, obesity, sedentary lifestyle, family history.

Digestion Key information

a. Digestion is a process that converts complex foodstuffs into simpler ones which can be readily absorbed by the gastrointestinal tract.
b. Stomach, duodenum and upper part of small intestine are the major sites of digestion. The small intestine is the prime site for the absorption of digested foods.
c. The digestion of carbohydrates is initiated in the mouth by salivary Alpha-amylase and is completed in the small intestine by pancreatic Alpha-amylase, oligosaccharidases and disaccharidases.
d. Monosaccharides are the final absorbable products of carbohydrate digestion. Glucose is transported into the intestinal mucosal cells by a carrier mediated, Na+-dependent energy requiring process.
e. Lactose intolerance due to a defect in the enzyme lactase (Beta-galactosidase) resulting in the inability to hydrolyse lactose (milk sugar) is the common abnormality of carbohydrate digestion.
f. Protein digestion begins in the stomach by pepsin, which is aided by gastric HCl. Pancreatic proteases (trypsin, chymotrypsin and elastase) and intestinal aminopeptidases and dipeptidases complete the degradation of proteins to amino acids and some dipeptides.
g. The intestinal absorption of amino acids occurs by different transport systems (at least six known). The uptake of amino acids is primarily a Na+-dependent energy requiring process.
h. Digestion of lipids occurs in the small intestine. Emulsification of lipids, brought about by bile salts, is a prerequisite for their digestion. Pancreatic lipase aided by a colipase degrades triacylglycerol to 2-monoacylglycerol and free fatty acids. Cholesterol esterase and phospholipases, respectively, hydrolyse cholesteryl esters and phospholipids.
i. Lipid absorption occurs through mixed micelles, formed by bile salts in association with products of lipid digestion (primarily 2-monoacylglycerol, cholesterol and free fatty acids). In the intestinal mucosal cells, lipids are resynthesized from the absorbed components and packed as chylomicrons which enter the lymphatic vessels and then the blood.
j. Dietary nucleic acids (DNA and RNA) are digested in the small intestine to nucleosides and/or bases (purines and pyrimidines) which are absorbed.

Functions of Liver, Lungs, and Kidneys

These three organs are vital for maintaining homeostasis (the body's internal balance) through processing, purification, and excretion.

1. Liver (The Metabolic Powerhouse & Detoxifier)

The liver is the largest gland and the primary metabolic organ.

- **Metabolic Regulation:** Controls blood sugar levels by storing glucose as **glycogen** (glycogenesis) and breaking it down when needed (glycogenolysis). It also metabolizes fats and proteins.
- **Detoxification:** Breaks down and removes toxins like drugs, alcohol, and metabolic waste (e.g., converting toxic ammonia into **urea**).
- **Bile Production:** Produces **bile**, which is essential for the **emulsification and digestion of fats** in the small intestine.
- **Synthesis:** Produces blood plasma proteins like **albumin** and **clotting factors** (e.g., fibrinogen).
- **Storage:** Stores key nutrients like glycogen, iron, and vitamins (A, D, E, K).

2. Lungs (The Gas Exchange Surface)

The lungs are the central organs of the respiratory system.

- **Gas Exchange:** Their primary function is **external respiration**.
  - **Oxygenation:** Oxygen (O_2) from inhaled air diffuses into the blood in the alveoli.
  - **Decarbonation:** Carbon dioxide (CO_2), a waste gas, diffuses from the blood into the alveoli to be **exhaled**.
- **pH Regulation:** Helps maintain the acid-base balance of the blood by controlling the level of CO_2 (a component of carbonic acid).
- **Vocalization:** Air moving through the larynx (voice box) enables speech and sound production.

3. Kidneys (The Master Chemists of Blood)

The kidneys are the main excretory organs that filter blood to form urine.

- **Waste Excretion:** Filter nitrogenous wastes (like **urea**, creatinine, and uric acid) from the blood and excrete them in **urine**.
- **Osmoregulation:** Regulate the water and electrolyte (e.g., Na^+, K^+, Cl^-) balance in the body to maintain blood pressure and volume.
- **Acid-Base Balance:** Maintain blood pH around 7.4 by excreting H^+ ions and reabsorbing bicarbonate (HCO_3^-) ions.
- **Endocrine Functions:**
  - Produce **renin** to regulate blood pressure.

- Produce **erythropoietin (EPO)**, which stimulates red blood cell production in the bone marrow.
- Convert vitamin D to its active form for calcium absorption.

Hormones

- Hormones are the organic substances, produced in minute quantities by specific tissues (endocrine glands) and secreted into the blood stream to control the biological activities in the target cells. They may be regarded as the chemical massengers involved in the regulation and coordination of body functions.
- Hormones are classified based on their chemical nature or mechanism of action. Chemically, they may be proteins or peptides (insulin, oxytocin), steroids (glucocorticoids, sex hormones) and amino acid derivatives (epinephrine, thyroxine). By virtue of the function, group I hormones bind to the intracellular receptors (estrogens, calcitriol), while group II hormones (ACTH, LH) bind to the cell surface receptors and act through the second messengers.
- Cyclic AMP (cAMP) is an intracellular second messenger for a majority of polypeptide hormones. Membrane bound adenylate cyclase enzyme, through the mediation of G proteins, is responsible for the synthesis of cAMP. cAMP acts through protein kinases that phosphorylate specific proteins which, in turn, cause the ultimate biochemical response. Phosphatidylinositol/calcium system also functions as a second messenger for certain hormones (TRH, gastrin).
- Hypothalamus is the master coordinator of hormonal action as it liberates certain releasing factors or hormones (TRH, CRH, GRH, GRIH) that stimulate or inhibit the corresponding trophic hormones from the anterior pituitary.
- Anterior pituitary gland is the master endocrine organ that produces several hormones which influence either directly or indirectly (through the mediation of other endocrine organs) a variety of biochemical processes in the body. For instance, growth hormone is directly involved in growth promoting process while TSH, FSH and ACTH, respectively influence thyroid gland, gonads and adrenal cortex to synthesize hormones.
- Thyroid gland produces two principal hormones—thyroxine (T4) and triiodothyronine (T3)—which are primarily concerned with the regulation of the metabolic activity of the body. Goiter is a disorder caused by enlargement of thyroid gland and is mainly due to iodine deficiency in the diet.
- Adrenal cortex synthesizes glucocorticoids (e.g. cortisol) that influence glucose, amino acid and fat metabolism, and mineralocorticoids (e.g. aldosterone) that regulate water and electrolyte balance. Androgens and estrogens (sex hormones) in small quantities are also synthesized by the adrenal cortex.

- Adrenal medulla produces two important hormones—epinephrine and norepinephrine (catecholamines). They influence diversified biochemical functions with an ultimate goal to mobilize energy resources and prepare the individual to meet emergencies (shock, anger, fatigue etc.)
- The steroid sex hormones, primarily androgens in males and estrogens in females, are respectively synthesized by the testes and ovaries. These hormones are responsible for growth, development, maintenance and regulation of reproductive system in either sex.
- Several gastrointestinal hormones (e.g. gastrin, secretin) have been identified that are closely involved in the regulation of digestion and absorption of foodstuffs.

Diagnostic Importance of Common Biomarkers

- **ALT (Alanine Aminotransferase): Specific marker for hepatocellular (liver cell) injury** (e.g., hepatitis, drug toxicity).
- **AST (Aspartate Aminotransferase):** Indicates liver damage but also elevated in **muscle injury** (less specific than ALT).
- **Alkaline Phosphatase (ALP):** Elevated in **biliary obstruction** (e.g., gallstones) and **bone disorders** (e.g., Paget's disease, bone metastases).
- **Bilirubin:** Marker for **jaundice**. Differentiates between pre-hepatic (hemolysis), hepatic (liver disease), and post-hepatic (obstructive) causes.
- **Albumin:** Measures the **synthetic function of the liver**; low in chronic liver disease.

B. Muscle & Tissue Damage

- **CK (Creatine Kinase): Marker for muscle damage**. CK-MB isoenzyme is specific for **heart muscle injury** (myocardial infarction). CK-MM for skeletal muscle damage.
- **LDH (Lactate Dehydrogenase):** A non-specific marker for **cell death**; elevated in MI, hemolysis, liver disease, and cancers.

C. Metabolic & Renal Function

- **Urea (BUN):** Indicator of **kidney function**. Elevated in renal failure, dehydration, high protein diet.
- **Uric Acid:** Elevated in **gout** and kidney stones. Also a marker for tumor lysis syndrome.
- **Glucose:** Key marker for diagnosing and monitoring **diabetes mellitus** (hyperglycemia) and hypoglycemia.

- **Cholesterol: Lipid profile** component. Elevated LDL is a major risk factor for **atherosclerosis and coronary artery disease**.

D. Bone & Mineral Metabolism

- **Calcium Ion (Ca^{2+}):** Abnormal levels indicate disorders of **parathyroid hormone**, bone metabolism, kidney disease, or malignancy.
- **Phosphate (PO_4^{3-}):** Imbalances are linked to **kidney disease**, bone disorders, and parathyroid dysfunction.
- **Acid Phosphatase (especially PSA): Prostatic Acid Phosphatase** was a historical marker for **prostate cancer** (now largely replaced by PSA).

E. Acid-Base Balance

- **Bicarbonate Ion (HCO_3^-):** A key measure in **acid-base balance**. Low in metabolic acidosis; high in metabolic alkalosis.

F. Hematological & Other

- **Iron Ion (Fe):** Key in diagnosing **iron-deficiency anemia** and iron-overload disorders like **hemochromatosis**.

Molecular Biology

DNA

a. The central dogma of life revolves around the flow of information from DNA to RNA, and from there to proteins.
b. Replication is a process in which DNA copies itself to produce identical daughter molecules of DNA. DNA replication is semiconservative, bidirectional and occurs by the formation of bubbles and forks.
c. Prokaryotic DNA syntheis is catalysed by the enzyme DNA polymerase III. This enzyme possesses proof-reading activity and edits the mistakes that might occur during nucleotide incorporation.
d. Replication in eukaryotes (particularly on the lagging strand) is more complex and involves several factors e.g. replication protein A, replication factor C, flap endonuclease.
e. Telomeres (repeat TTAGGG sequences) are the special structures that prevent the continuous loss of DNA at the end of the chromosome during the course of replication.

f. Recombination involves the exchange of genetic information through the exchange of DNA. Transposition refers to the movement of specific pieces of DNA (called transposons) in the genome.
g. Damage to DNA may be due to single base alteration, two-base alteration, chain breaks and cross linkages. The cells possess an inbuilt system to repair the damaged DNA

Transcription and Translation

Transcription and Translation

a. Transcription is the process in which RNA is synthesized from DNA, which is carried out in 3 stages–initiation, elongation and termination.
b. In case of prokaryotes, a single enzyme synthesizes all the RNAs. In eukaryotes, RNA polymerase I, II and III respectively catalyse the formation of rRNAs, mRNAs and tRNAs.
c. The primary mRNA transcript (i.e. hnRNA) undergoes post-transcriptional modifications e.g. base modifications, splicing etc.
d. Reverse transcription is the process of synthesizing DNA from RNA by the enzyme reverse transcriptase.
e. Biosynthesis of a protein or a polypeptide is known as translation. The amino acid sequence of a protein is determined by the triplet nucleoside base sequences of mRNA, arranged as codons.
f. The genetic code (codons)–composed of A, G, C and U–is universal, specific, nonoverlapping and degenerate. Of the 64 codons, three (UAA, UAG, UGA) are termination codons while the rest code for amino acids.
g. Ribosomes are the factories of protein biosynthesis. Translation involves activation of amino acids, protein synthesis proper (initiation, elongation and termination), protein folding and post-translational modifications.
h. The post-translational modifications include proteolytic degradation, intein splicing and covalent modifications (phosphorylation, hydroxylation, glycosylation etc.). These modifications are required to make the proteins biologically active.
i. The proteins synthesized in translation reach the destination to exhibit their biological activity. This is carried out by a process called protein targeting or protein sorting.
j. The mitochondria possess independent DNA with the machinery for transcription and translation. However, only a few proteins (around 13) are actually synthesized in the mitochondria.

Gene Regulation

a. DNA, the chemical vehicle of heredity, is composed of genes. The regulation of gene expression is absolutely essential for the growth, development and differentiation of an organism. A positive regulation increases gene expression while a negative regulation decreases.
b. The operon is the coordinated unit of gene expression. The lac operon of E. coli consists of regulatory genes and structural genes. The lac repressor binds to the DNA and halts the process of transcription of structural genes. However, the presence of lactose inactivates the repressor (derepression) leading to the expression of structural genes.

c. The **Lac operon** is an inducible genetic regulatory system found in *E. coli* that allows the bacterium to efficiently metabolize lactose. Its key feature is **dual regulation**: **Negative Control by the Repressor:** The operon is normally "off." A repressor protein binds to the operator, preventing transcription. The presence of lactose (inducer) inactivates the repressor, allowing transcription to proceed. **Positive Control by CAP-cAMP:** When glucose is absent, cAMP levels rise. cAMP binds to the Catabolite Activator Protein (CAP), and the complex binds to the promoter, significantly **enhancing transcription** only if the repressor is removed. In essence, the Lac operon is maximally expressed only when **lactose is present** and **glucose is absent**, making it a classic example of how prokaryotes efficiently regulate gene expression in response to environmental nutrients.

d. The arabinose (ara) operon is an inducible system in E. coli for metabolizing the sugar arabinose. It has a unique regulatory protein, AraC, which can act as both a repressor and an activator. When arabinose is absent, AraC dimerizes and forms a DNA loop, repressing transcription. When arabinose is present, it binds to AraC, changing its shape and breaking the loop. The AraC-arabinose complex then binds to the ara promoter and activates transcription. Like the lac operon, it also requires CAP-cAMP for full activation when glucose is low. This dual control ensures the genes are only expressed when arabinose is available and glucose is not.

Recombinant DNA Technology:

a. Recombinant DNA (rDNA) technology is primarily concerned with the manipulation of genetic material (DNA) to achieve the desired goal in a pre-determined way.
b. The procedure for rDNA technology involves molecular tools (enzymes e.g. restriction endonucleases), host cells (E. coli, S. cerevisiae), vectors (plasmids, bacteriophages), gene transfer (transformation, electroporation) and the strategies of gene cloning.
c. Blotting techniques are employed for the identification of desired DNA (Southern blot), RNA (Northern blot), and protein (Western blot).

d. Polymerase chain reaction is an in vitro technique for generating large quantities of a specified DNA i.e. cell-free amplification.
e. Gene libraries or genomic libraries represents the collection of DNA fragments (i.e. genes) from a genome of a particular species.
f. Site-directed mutagenesis is the technique for generating amino acid coding changes in the DNA (gene) to produce a desired protein/enzyme.
g. Analysis of DNA (i.e. detection of gene/genes) can be used as a diagnostic system for the detection of many pathogenic and genetic diseases e.g. tuberculosis, malaria, AIDS, sickle-cell anemia, certain cancers.
h. DNA fingerprinting or DNA profiling is the present day genetic detective in the practice of modern medical forensics. Four types of DNA markers are used in DNA fingerprinting– RFLFs, VNTRs, STRs, and SNPs.
i. Many pharmaceutical compounds of health importance (for disease treatment) are being produced by rDNA technology e.g. insulin, growth hormone, interferons, erythropoietin, hepatitis B vaccine.
j. Transgenic animals can be developed by introducing a foreign DNA (transgene). These animals are genetically modified or engineered with new heritable characters e.g. oncomouse, knockout mouse, prostate mouse.

Human Genome Project

a. Human Genome Project is an international venture involving several laboratories, and a large number of scientists and technicians from various disciplines.
b. About 90% of the human genome has been sequenced. It is composed of 3.2 billion base pairs.
c. The total number of genes in the humans is in the range of 30,000–40,000.
d. About 1.1–1.5% of the human genome codes for proteins while the remaining portion is regarded as junk DNA (composed of introns and intergenic sequences).
e. Human genome sequencing has wide range of applications–better understanding of genetic diseases, improvements in gene therapy, development of pharmacogenomics, and advancement of biotechnology.

৪৯ তম বিসিএস প্রাণরসায়নের জন্যে শেষ মুহূর্তের প্রস্তুতিঃ

- ✓ সিলেবাস ধরে পড়া রিভিশন দিন, পরীক্ষার ফোকাসে থাকুন, বায়োকেমিস্ট্রি জানার শেষ নাই।
- ✓ প্রত্যেকটি মেজর টপিকের কনসেপ্ট ক্লিয়ার রাখুন
- ✓ কোন টপিকের একদম টারমিনাল ডিসকাসনে যাওয়া যাবে না। কনসেপ্টুয়াল আলোচনাই বিসিএসের জন্যে অধিক উপযোগী।

- ✓ গুরুত্বপূর্ণ বিক্রিয়া ও কেমিক্যাল স্ট্রাকচার সমূহ মুখস্ত রাখুন। যেমন, এমাইনো এসিড, লিপিড গ্রুপ, কাবোহাইড্রেট গ্রুপ।
- ✓ সিনথেটিক রিয়েকশান থেকে ক্যাটাবলিক পাথওয়ে সমূহকে বেশি গুরুত্ব দিন। যেমনঃ গ্লাইকোলাইসিস, টিসিএ সাইকেল,ইউরিয়া সাইকেল, বিটা অক্সিডেশন ইত্যাদি।

রেফারেন্স বইঃ

- ✓ যে সকল টপিক এইচএসসির সাথে ওভারলেপ রয়েছে সেগুলো এইচএসসির টেক্সট বই থেকে রিভাইজ দিবেন।
- ✓ স্নাতকের টেক্সট বই হিসেবে লেনিজার বায়োকেমিস্ট্রি (ষষ্ঠ/সপ্তম মুদ্রন) এবং সত্য নারায়নের বায়োকেমিস্ট্রি বই দেখতে পারেন।
- ✓ লাস্ট মোমেন্টে ফিজিওলজি/এন্ডোক্রাইনোলজির জন্যে মেডিক্যাল টেক্সটবুক এর বদলে এইচএসসি জীববিজ্ঞান ২য় পত্র গাজী আজমল স্যার এর বইটা দেখতে পারেন।

পড়াশোনার কৌশলঃ

- ✓ প্রতিদিনই জেনারেল পার্ট এর পাশাপাশি বায়োকেমিস্ট্রি পড়বেন। মনে রাখবেন ২০০ নম্বরের মধ্যে যে এগিয়ে থাকবে সেই টিকবে।
- ✓ বিজ্ঞানের, বিশেষত বায়োকেমিস্ট্রির মত একটা বিষয় থেকে স্নাতক শেষ করে আলাদা করে বিসিএসের প্রস্তুতি নেয়া চ্যালেঞ্জিং। তাই সাবজেক্টিভে এগিয়ে থাকলে এটা বাড়তি সুবিধা দিবে।
- ✓ বড় বড় বিক্রিয়া, বা মেকানিজম এড়িয়ে যান। এখানে প্রিলিমিনারি এক্সাম দিবেন।
- ✓ টপিকের মূল তথ্য সমূহ নিয়ে নিজে অতি সংক্ষিপ্ত নোট করতে পারেন।
- ✓ অবশ্যই সবগুলো ক্লাস টেস্ট দিবেন ও ব্যাখা দেখবেন।
- ✓ টাইম ম্যানেজমেন্ট এর জন্যে ফুল মডেল টেস্ট দিতে হবে মাস্ট।
- ✓ ক্যালকুলেটর ছাড়া ছোটখাট গানিতিক সমস্যা সমাধানের জন্যে মানষিক প্রস্তুনি নিন।

পরীক্ষার আগে করনীয়ঃ

ভালো ফল করার জন্য আগের রাতে পর্যাপ্ত ঘুম, সঠিক খাদ্যাভ্যাস এবং পরীক্ষার জন্য প্রয়োজনীয় জিনিসপত্র গুছিয়ে রাখা জরুরি।

পরীক্ষার আগে নতুন করে কিছু না পড়ে পুরানো পড়াগুলো দ্রুত দেখে নেওয়া এবং মানসিক চাপ মুক্ত থাকা উচিত, যা পরীক্ষার হলে আত্মবিশ্বাস বাড়াতে সাহায্য করবে।

শারীরিক প্রস্তুতি:

- ✓ পর্যাপ্ত ঘুম: পরীক্ষার আগের রাতে অবশ্যই পর্যাপ্ত ঘুম নিশ্চিত করুন। তবে পরীক্ষার টেনশনে অনেকেরই আগের রাতে ঘুম আসে না। আমার পরামর্শ হলো, আগের দিন দিনের বেলার কোন ভাবেই ঘুমাবেন না। ২-৩ ঘন্টা রোদে থাকুন বা রোদের দিকে তাকিয়ে কাজ করুন, রাত দ্রুত ঘুম আসতে বাধ্য। হ্যা, বিকেলের পর চা কফি খাবেন না।

- ✓ সঠিক খাদ্যাভ্যাস: পরীক্ষা শুরুর আগে অবশ্যই নাস্তা করে যাবেন। ভারী খাবার না খেয়ে পুষ্টিকর ও হালকা খাবার খান, যা আপনাকে চনমনে রাখতে সাহায্য করবে।

মানসিক প্রস্তুতি:

- ✓ ইতিবাচক থাকুন: পরীক্ষার আগে মানসিক চাপ কমাতে হালকা ব্যায়াম বা পছন্দের কোনো গান শুনতে পারেন। ইতিবাচক মনোভাব ধরে রাখলে আত্মবিশ্বাস বাড়ে।
- ✓ আগের পড়া ঝালাই: নতুন করে কিছু না পড়ে, আগের পড়াগুলো দ্রুত রিভিশন দিন। সকালে মস্তিষ্ক সতেজ থাকে, তাই এই সময় রিভিশন করলে ভালো মনে থাকবে।

পরীক্ষার জিনিসপত্র গোছানো:

- ➢ প্রয়োজনীয় উপকরণ: পরীক্ষার জন্য প্রয়োজনীয় সব জিনিস, যেমন—প্রবেশপত্র, রেজিস্ট্রেশন কার্ড, কলম, পেন্সিল, স্কেল, এবং অন্যান্য জরুরি উপকরণ একটি স্বচ্ছ ব্যাগে গুছিয়ে রাখুন।
- ➢ সময়সূচী হাতের কাছে: পরীক্ষার সময়সূচী এবং পরীক্ষার কেন্দ্র সম্পর্কে জেনে রাখুন। পরীক্ষা শুরু হওয়ার অন্তত ৩০ মিনিট আগে কেন্দ্রে উপস্থিত হন।

অন্যান্য গুরুত্বপূর্ণ বিষয়:

- ➢ প্রশ্নপত্র ভালোভাবে পড়া: পরীক্ষার হলে বসে প্রথমেই প্রশ্নপত্রটি ভালো করে পড়ে নিন। এতে সময় ভাগ করে নিতে এবং কোন প্রশ্ন আগে উত্তর করবেন তা ঠিক করতে সুবিধা হবে। আমার পরামর্শ হলো, আগে জেনারেল অংশের ম্যাথ মেন্টাল সবার পরে দাগাবেন।
- ➢ ভুল থেকে শেখা: কোনো বিষয়ে আটকে গেলে পরের প্রশ্নে চলে যান। পরে সময় পেলে আবার সেটা দেখে নিন। ভুল উত্তর দিয়ে খামোখা নেগেটিভ খাবেন না। যতটা পারেন ততটাই দাগাবেন।

পরীক্ষার জন্যে সর্বাধিক গুরুত্বপূর্ণ ২০০ এমসিকিউ:

1. In Rutherford's a-scattering experiment what substance coated screen was used?

ক) PbS খ) FeS গ) ZnS ঘ) CuS

Answer: ZnS

Explanation: **Zinc Sulfide (ZnS) was used in the Rutherford gold foil experiment as the scintillation screen—its job was to detect the alpha particles by converting their kinetic energy into tiny, visible flashes of light (called scintillations).**

2. What is the value for mvr of an electron in 3rd energy level?

ক(nh/π খ (3h/2π গ (nh/mΦ ঘ (nrΔhμ

Answer: খ (3h/2π

Explanation:

$$mvr = \frac{nh}{2\pi}$$

where, m = mass of the electron

v = velocity of the electron

n = orbit number in which electron is present

r = radius of the orbit

3. If E_1 is the energy of 1st orbit of H-atom, then what is its energy of 3rd orbit?

ক(E1× (1/9) খ(E1×9 গ (E1× (1/3) ঘ (E1×3

Answer: ক(E1× (1/9)

Explanation:

Calculation:

Substitute the given values into the formula:

$$(4\ \text{atm}) \times (2\ \text{L}) = (8\ \text{atm}) \times V_2$$

$$8\ \text{atm} \cdot \text{L} = (8\ \text{atm}) \times V_2$$

Now, solve for

$$V_2$$

:

$$V_2 = \frac{8\ \text{atm} \cdot \text{L}}{8\ \text{atm}}$$

$$V_2 = 1\ \text{L}$$

Therefore, the volume of the gas at a pressure of 8 atm will be 1 L.

4. If a gas has an initial pressure of 4 atm at 2 L, what will be the volume at 8 atm (constant temperature)?

ক (1L খ (0.5L গ (4L ঘ (0.25L

Answer: ক (1L

Explanation:

For a hydrogen atom, according to **Bohr's model**:

$$E_n = \frac{E_1}{n^2}$$

Where:

- E_n = energy of the electron in the n^{th} orbit
- E_1 = energy in the first orbit ($n = 1$)
- n = principal quantum number

For the **3rd orbit** ($n = 3$):

$$E_3 = \frac{E_1}{3^2} = \frac{E_1}{9}$$

✅ Therefore, the energy of the 3rd orbit is $E_1 \times \frac{1}{9}$.

5. If 2 L of gas at 300 K is heated to 600 K at constant pressure, its volume will be:

ক (2L খ (4L গ (1L ঘ (6L

Answer: 4L

Explanation:

$$V_2 = \frac{2\ \text{L}}{300\ \text{K}} \times 600\ \text{K}$$

$$V_2 = 2\ \text{L} \times 2$$

$$V_2 = 4\ \text{L}$$

Since the temperature doubles from 300 K to 600 K, the volume also doubles from 2 L to 4 L, as per the direct relationship described by Charles's Law.

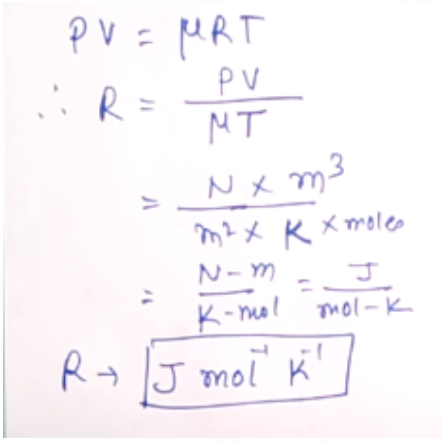
6. The SI unit of the universal gas constant R is:

ক) J $mol^{-1}K^{-1}$ খ) L atm mol^{-1} K^{-1}

গ) Both A and B are correct units ঘ) None of these

Answer: ক (J mol-1K-1

Explanation:



7. Dalton's Law of Partial pressure fails when

ক (Gas are not ideal gas　　খ (Gases reacts each other

গ (Have very low density　　ঘ (Above critical temperature

Answer: খ (Gases reacts each other

Explanation: Reaction among gases disrupts the relation of Partial Pressure

8. The term (V-mb) in the equation of real gas accounts for:

ক) Increase in kinetic energy　　খ) Pressure correction

গ) Increase in temperature　　ঘ (Free volume available for molecular motion

Answer: ঘ (Free volume available for molecular motion

Explanation:

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = RT$$

P: Pressure　　V: Volume

T: Temperature　　R: Gas constant

n: Number of moles of the gas

a: Intermolecular attractive force

b: Volume occupied by one mole of the gas

9. The line obtained from the Boyle's Law known as

ক) isobar　　খ) isotherm　　গ) isomolar　　ঘ) isotope

Answer: খ (isotherm

Explanation: Boyle's Law works at constant temperature and graph known a isotherm

10. Under which conditions does a real gas behave most like an ideal gas?

ক) High pressure and low temperature　　খ (Low pressure and high temperature

গ) High pressure and high temperature　　ঘ) Low pressure and low temperature

Correct Answer: b) Low pressure and high temperature.

Explanation: At low pressure, the particles are far apart, so their volume is negligible compared to the container volume. At high temperature, the particles move quickly, so intermolecular forces are negligible. These are the conditions where a real gas behaves most ideally.

11. Which of the following would cause a negative deviation from the Ideal Gas Law (PV=nRT)?

ক (Strong intermolecular attractive forces　　খ) High kinetic energy of gas particles

গ) Significant volume occupied by gas particles　　ঘ) Perfectly elastic collisions

Correct Answer: a) Strong intermolecular attractive forces.

Explanation: A negative deviation means that the real gas pressure is lower than the pressure predicted by the ideal gas law. This occurs because attractive forces between gas particles pull

them toward each other, reducing the force and frequency of their collisions with the container walls.

12. Whose electron distribution is similar to Al^{+3} ion?

ক) O^- খ (F- গ) Cl^- ঘ) Mg^{+2}

Answer: F-

Explanation: $Al^{+3} = 1S^2\ 2S^2\ 2P^4$

$F^- = 1S^2\ 2S^2\ 2P^4$

13. Which can form giant molecule?

ক) CO_2 খ) SiO2 গ) CO ঘ) NO_2

Answer: খ (SiO2

Explanation: SiO^2 show catenation property and form giant molecule. This is why it has higher melting point.

14. Which set is correct in size?

ক) Al > Mg > Na খ) Na > Ne > F

গ) $Al^{3+} > Mg^{2+} > Na^+$ ঘ (Na+ > Mg2+ > Al3+

Answer: ঘ (Na+ > Mg2+ > Al3+

Explanation: Since the nuclear charge increases in the order Na < Mg < Al, the pull on the 10 electrons becomes stronger, making the ionic radius smaller.

Therefore, the correct order of ionic size is

$Na^+ > Mg^{2+} > Al^{3+}$

15. Which of the following equations is for ideal gas?

ক (PV = nRT খ) $PV = 1/3\ mNc^2$

গ) PV = RT ঘ) $P_1V_1 = P_2V_2$

Answer: PV = nRT is the equation for ideal Gas.

16. What is the compressibility factor for ideal gas?

ক (1.0 খ) 2.0 গ) 0.5 ঘ) 3.0

Answer: ক (1.0

Explanation: Ideal gas have compressibility factor=1.

17. At constant temperature with increases pressure, what is the destiny of ideal gas?

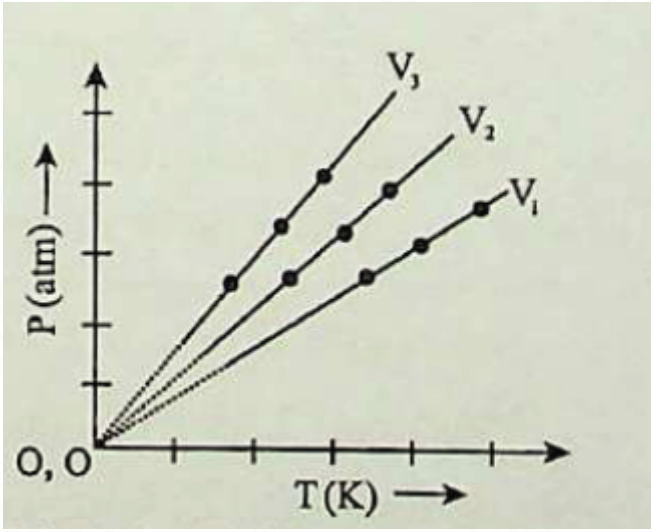
ক) Increased খ) Decreased

গ) Zero ঘ (Constant

Answer: ঘ (Constant

Explanation: In a constant temperature, change of pressure doesn't change the product of PV, thus constant.

18. The graph known as:



ক) isobar

খ) isotherm

গ (isochor

ঘ) isovol

Answer: গ (isochor

Explanation: This is Lusaac's Law and the straight line at constant volume known as isochor

19. According to the first law of thermodynamics, which of the following is true?

ক (The total energy of the universe is constant.

খ) Heat always flows from a hotter body to a colder body.

গ) The entropy of the universe always increases in a spontaneous process.

ঘ) The heat absorbed by a system is equal to the work done on the system.

Correct Answer: A) The total energy of the universe is constant.

Explanation: The first law of thermodynamics, also known as the law of conservation of energy, states that energy cannot be created or destroyed, only transferred or transformed.

20. Which of the following statements about enthalpy (ΔH) is correct?

ক (It is the measure of the disorder of a system.

খ (It represents the heat absorbed or released in a reaction at constant pressure.

গ) It is always positive for an exothermic reaction.

ঘ) It is a measure of the spontaneity of a reaction.

Correct Answer: B) It represents the heat absorbed or released in a reaction at constant pressure.

Explanation: Enthalpy change (ΔH) is the heat exchanged with the surroundings at constant pressure. A negative ΔH indicates an exothermic reaction (releasing heat), and a positive ΔH indicates an endothermic reaction (absorbing heat).

21. The second law of thermodynamics states that:

ক) The total energy of the universe is constant.

খ) The entropy of the universe is constantly decreasing.

গ (The entropy of the universe always increases in a spontaneous process.

ঘ) It is impossible to convert heat completely into work in a cyclic process.

Correct Answer: C) The entropy of the universe always increases in a spontaneous process.
Explanation: The second law of thermodynamics states that for any spontaneous process, the total entropy of the universe (system + surroundings) must increase (ΔS universe >0).

22. For a spontaneous process, the change in Gibbs free energy (ΔG) must be:

ক) Positive

খ (Negative

গ) Zero

ঘ) Independent of temperature

Correct Answer: B) Negative

Explanation: A process is spontaneous when the Gibbs free energy change (ΔG) is negative. This indicates that the system is moving towards a lower, more stable energy state.

23. The Gibbs-Helmholtz equation relates Gibbs free energy (ΔG), enthalpy (ΔH), and entropy (ΔS) changes. What is the correct form of this equation?

ক (ΔG=ΔH+TΔS

খ (ΔG= ΔH-TΔS

গ) ΔH=ΔG-TΔS

ঘ) ΔS=ΔG-TΔH

Correct Answer: B) ΔG=ΔH-TΔS

Explanation: The Gibbs-Helmholtz equation is ΔG=ΔH-TΔS, where T is the absolute temperature. This equation is fundamental for predicting the spontaneity of a reaction.

24. A reaction with a negative ΔH and a positive ΔS is:

ক (Always spontaneous

খ (Never spontaneous

গ (Spontaneous only at low temperatures

ঘ (Spontaneous only at high temperatures

Answer: ক (Always spontaneous

Explanation: The Gibbs-Helmholtz equation is ΔG=ΔH-TΔS. If ΔH is negative and ΔS is positive, the term -TΔS will be negative, making ΔG negative regardless of the temperature, so the reaction is always spontaneous.

25. Which of the following processes has a positive entropy change (ΔS > 0)?

ক) Freezing of water

খ) Condensation of steam

গ (A gas expanding into a vacuum

ঘ) Formation of a crystalline solid from its ions in solution

Answer: গ (A gas expanding into a vacuum

Explanation: A gas expanding into a vacuum increases the volume and disorder of the system, leading to a positive change in entropy. The other options involve a decrease in disorder.

26. What is the significance of the point where ΔG=0?

ক) The reaction is spontaneous.

খ) The reaction is non-spontaneous.

গ (The system is at equilibrium.

ঘ) The reaction rate is at its maximum.

Answer: গ (The system is at equilibrium.

Explanation: When ΔG = 0, the forward and reverse reaction rates are equal, and there is no net change in the concentrations of reactants and products. The system is in a state of chemical equilibrium.

27. The relationship between ΔH, ΔU, and PΔV is given by:

ক (ΔH=ΔU+PΔV　　খ) ΔU= ΔH+PΔV

গ) ΔH = ΔU – PΔV　　ঘ) ΔU = ΔH-PΔV

Answer: ক (ΔH=ΔU+PΔV

Enthalpy (H) is defined as H=U+PV. Therefore, at constant pressure, the change in enthalpy is ΔH=ΔU+PΔV.

28. Which of the following is NOT a colligative property of a solution?

ক) Boiling point elevation　　খ) Freezing point depression

গ) Osmotic pressure　　ঘ (Surface tension

Answer: ঘ (Surface tension

Explanation: Colligative properties depend only on the number of solute particles in a solution, not on their identity. Surface tension is a property of the substance itself and is not a colligative property.

29. The phenomenon of osmosis can be defined as:

ক) The movement of solute molecules from a high concentration to a low concentration.

খ) The movement of solvent molecules from a low concentration to a high concentration through a semi-permeable membrane.

গ (The movement of solvent molecules from a high concentration to a low concentration through a semi-permeable membrane.

ঘ) The movement of both solute and solvent molecules through a semi-permeable membrane.

Answer: গ) The movement of solvent molecules from a high concentration to a low concentration through a semi-permeable membrane.

Explanation: Osmosis is the net movement of solvent molecules across a semi-permeable membrane from a region of higher solvent concentration to a region of lower solvent concentration.

30. Which of the following is a type of solution?

ক) Suspension　　খ) Colloid

গ (Homogeneous mixture　　ঘ) Heterogeneous mixture

Answer: গ (Homogeneous mixture

Explanation: A solution is a homogeneous mixture where the components are uniformly distributed. Suspensions and colloids are heterogeneous mixtures.

31. What is the conjugate base of the dihydrogen phosphate ion, $H_2PO_4^-$?

ক) H_3PO_4　　খ) HPO_4^{2-}

গ) PO_4^{3-}　　ঘ) H_3O^+

Answer: খ) HPO_4^{2-}

Explanation: A conjugate base is what remains after an acid has donated a proton (H^+). When the dihydrogen phosphate ion ($H_2PO_4^-$) acts as an acid, it loses one proton, resulting in the hydrogen phosphate ion (HPO_4^{2-}).

32. In the reaction HCl + H_2O ⇌ H_3O^+ + Cl^-, which species acts as a Brønsted-Lowry base?

ক) HCl খ) H2O গ) H3O+ ঘ) Cl-

Answer: খ) H2O

Explanation: According to the Brønsted-Lowry definition, a base is a substance that accepts a proton. In this reaction, water (H2O) accepts a proton from hydrochloric acid (HCl) to form the hydronium ion (H3O+).

33. What is the pH of a 0.01 M solution of potassium hydroxide (KOH)?

ক) 2 খ) 12 গ) 1 ঘ) 13

Answer: খ) 12

Explanation: KOH is a strong base and dissociates completely. The hydroxide ion concentration $[OH^-]$ is 0.01 M, or 10^{-2} M. The pOH is calculated as $-\log[OH^-]$, so $pOH = -\log(10^{-2}) = 2$. The relationship between pH and pOH is $pH + pOH = 14$. Therefore, $pH = 14 - 2 = 12$.

34. Which of the following mixtures would result in an effective buffer solution?

ক) HCl and NaCl খ) NaOH and NaCl

গ) CH3COOH and CH3COONa ঘ) HCl and NaOH

Answer: গ) CH3COOH and CH3COONa

Explanation: A buffer solution is created by mixing a weak acid with its conjugate base (or a weak base with its conjugate acid). Acetic acid (CH3COOH) is a weak acid, and sodium acetate (CH3COONa) provides its conjugate base, the acetate ion (CH3COO-).

35. The primary physiological buffer system in human blood is the:

ক) Phosphate buffer system খ) Hemoglobin buffer system

গ) Bicarbonate buffer system ঘ) Sulfate buffer system

Answer: গ) Bicarbonate buffer system

Explanation: The bicarbonate buffer system, composed of carbonic acid (H2CO3) and the bicarbonate ion (HCO3-), is the most important buffer in the blood, maintaining its pH within the narrow range of 7.35 to 7.45.

36. The buffering capacity of a buffer is at its maximum when:

ক) The concentration of the weak acid is much higher than its conjugate base

খ) The concentration of the conjugate base is much higher than the weak acid

গ) pH = pKa

ঘ) The total concentration of the buffer is low

Answer: গ) pH = pKa

Explanation: Buffering capacity refers to the ability of a buffer to resist pH change. This ability is greatest when the concentrations of the weak acid and its conjugate base are equal, which is the point where the pH of the solution is equal to the pKa of the acid.

37. The ion product of water, Kw, at 25°C is 1.0×10^{-14}. What is the concentration of OH-ions in pure water at this temperature?

ক) 1.0×10^{-14} M
খ) 1.0×10-7 M
গ) 1.0 M
ঘ) 7.0 M

Ans: খ) 1.0×10-7 M

Explanation: In pure, neutral water, the concentrations of hydrogen ions $[H^+]$ and hydroxide ions $[OH^-]$ are equal. Since $K_w = [H^+][OH^-] = 1.0 \times 10^{-14}$, we have $[OH^-]^2 = 1.0 \times 10^{-14}$. Taking the square root gives $[OH^-] = 1.0 \times 10^{-7}$ M.

38. Beer's Law states that absorbance is directly proportional to the:

ক) Wavelength of light
খ) Path length
গ) Concentration of the solute
ঘ) Intensity of transmitted light

Answer: গ) Concentration of the solute

Explanation: The Beer-Lambert law is given by the equation A=ϵbc, where A is absorbance, ϵ is the molar absorptivity, b is the path length, and c is the concentration. This equation shows a direct, linear relationship between absorbance and concentration.

39. Optical Density (OD) is mathematically defined as:

ক) $\log_{10}(I_t/I_0)$
খ) $-\log_{10}(I_0/I_t)$
গ) $\log_{10}(I_0/I_t)$
ঘ) I_t/I_0

Answer: $\log_{10}(I_0/I_t)$

Explanation: Optical Density (OD) is another term for absorbance. It is defined as the base-10 logarithm of the ratio of the intensity of light that enters the sample (I_0) to the intensity of light that passes through it (I_t).

40. The purpose of using a "blank" in spectrophotometry is to:

ক) Calibrate the light source intensity
খ) Correct for absorbance due to the solvent and the cuvette
গ) Set the wavelength to its maximum absorbance
ঘ) Ensure the sample concentration is within the linear range

Answer: খ) Correct for absorbance due to the solvent and the cuvette

Explanation: The "blank" contains the solvent and any other reagents in the sample except for the substance being measured. By zeroing the spectrophotometer with the blank, you ensure that the measured absorbance is solely due to the substance of interest and not from the container or the solvent.

41. To determine the concentration of a purified DNA sample, you should measure its absorbance at:

ক) 230 nm খ) 260 nm

গ) 280 nm ঘ) 595 nm

Answer: 260 nm

Explanation: The nitrogenous bases in nucleic acids (adenine, guanine, cytosine, thymine, uracil) have a characteristic maximum light absorbance at a wavelength of 260 nm. This property is used to quantify DNA and RNA

42. The Henderson-Hasselbalch equation is most useful for:

ক) Calculating the pH of strong acid solutions

খ) Determining the rate of a chemical reaction

গ) Calculating the pH of a buffer solution

ঘ) Measuring the concentration of a substance using spectrophotometry

Answer: গ) Calculating the pH of a buffer solution

Explanation:

The Henderson-Hasselbalch equation is most useful for:

Correct Answer: C) Calculating the pH of a buffer solution

Explanation: This equation ($pH = pK_a + \log(\frac{[A^-]}{[HA]})$) is specifically designed to calculate the pH of a buffer solution when the pK_a and the concentrations of the weak acid and its conjugate base are known.

43. The reagent can be used to differentiate between ethanal and butanone:

ক) Lucas reagent খ) Tolen reagent

গ) Lewis acid ঘ) Indophenol

Answer: Tolen reagent

Explanation: Aldehyde produce silver mirror reacting with Tolen Reagent thus it can be differentiate between any aldehyde and ketone.

44. Which reagent can distinguish between an alkane and an alkene?

ক) Bromine water খ) Conc. H_2SO_4

গ) $KMnO_4$ ঘ) A and C

Answer: A and C

Explanation: Reagent to distinguish between alkane and alkene: Bromine water & $KMnO_4$ (D) Alkanes do not react with bromine water in dark, while alkenes decolorize it. Alkenes also get oxidized by alkaline $KMnO_4$ (Baeyer's test).

45. The major product formed when 2-butene reacts with HBr in the presence of peroxides is:

ক) 2-Bromobutane খ) 1-Bromobutane

গ) 3-Bromobutane ঘ) 2, 3 – Dibromobutane

Answer: 1-Bromobutane

Explanation: Major product of 2-butene + HBr (with peroxides): 1-Bromobutane (B)
Peroxide effect (Kharasch effect) → anti-Markovnikov addition of HBr to alkenes. So Br attaches to terminal carbon → 1-bromobutane.

46. Which reagent is used to distinguish between primary, secondary and tertiary alcohols?

ক) Lucas reagent খ) Tollen's reagent
গ) Fehling's solution ঘ) Bromine water

Answer: Lucas reagent

Explanation: Lucas reagent = HCl + $ZnCl_2$. Tertiary alcohols react instantly, secondary moderately, primary slowly → turbidity test.

47. Dehydration of ethanol in the presence of concentrated H_2SO_4 gives:

ক) Ethane খ) Ethene
গ) Acetaldehyde ঘ) Ethyl hydrogen sulfate

Answer: Ethene

Explanation: Dehydration of ethanol with conc. H_2SO_4: Ethene (B)
Conc. H_2SO_4 acts as dehydrating agent at 170°C → ethanol → ethene.

48. Which test is positive for aldehydes but not for ketones?

ক) 2,4-DNP test খ) Fehling's test
গ) Iodoform test ঘ) Brady's test

Answer: খ) Fehling's test

Explanation: Test positive for aldehydes, not ketones: Fehling's test (B)
Aldehydes reduce Fehling's solution to red Cu_2O, ketones generally do not.

49. Acetone reacts with iodine and NaOH to give a yellow precipitate. This reaction is called:

ক) Cannizzaro reaction খ) Aldol condensation
গ) Iodoform test ঘ) Wolff-Kishner reduction

Answer: গ) Iodoform test

Explanation: Acetone + I_2/NaOH gives yellow ppt: Iodoform test (C)
Methyl ketones ($-COCH_3$ group) undergo iodoform reaction → yellow CHI_3 ppt.

50. Which of the following shows both acidic and basic character?

ক) Acetic acid খ) Amide গ) Ester ঘ) Aldehyde

Answer: Amide

Explanation: Compound with both acidic & basic character: Amide (B)
$-CONH_2$ has lone pair on N (basic) and carbonyl group (weakly acidic).

51. Which one acts as an electrophile?

ক) NH_3 খ) H_2O গ) OH^- ঘ) $AlCl_3$

Answer: $AlCl_3$

Explanation: Here $AlCl_3$ is a neutral electrophile which has attraction for electron.

52. Which one is used in heart disease?

ক) paracetamol খ) nitroglycerine গ) naphthalene ঘ) glycine

Answer: Nitroglycerine

Explanation: Nitroglycerin is used to prevent angina (chest pain) caused by coronary artery disease. This medicine is also used to relieve an angina attack that is already occurring.

53. Phenol is more acidic than cyclohexanol. This is due to:

ক) The inductive effect of the benzene ring.

খ) The greater stability of the phenoxide ion due to resonance.

গ) The steric hindrance of the hydroxyl group in cyclohexanol.

ঘ) The aromatic character of phenol.

Answer: খ) The greater stability of the phenoxide ion due to resonance.

Explanation: The acidity of an alcohol or phenol is determined by the stability of its conjugate base. When phenol loses a proton, it forms the phenoxide ion. The negative charge on the oxygen atom can be delocalized into the benzene ring via resonance, stabilizing the ion and making the conjugate acid (phenol) more acidic. In contrast, the conjugate base of cyclohexanol (the cyclohexoxide ion) has no resonance stabilization.

54. Which of the following compounds is an aromatic amine?

ক) Methylamine খ) Cyclohexylamine

গ) Aniline ঘ) Toluene

Answer: Aniline

Explanation: An aromatic amine is a compound where the amino group ($-NH_2$) is directly attached to an aromatic ring. Aniline fits this description as it is a benzene ring bonded to an amino group. Methylamine is an aliphatic amine, cyclohexylamine is a cyclic aliphatic amine, and toluene is an aromatic hydrocarbon.

55. The reaction of benzene diazonium chloride with H2O and heat will produce which of the following?

ক) Chlorobenzene খ) Phenol

গ) Nitrobenzene ঘ) Aniline

Answer: Phenol

Explanation: When benzene diazonium chloride is heated with water, the diazonium group is replaced by a hydroxyl group, a process known as hydrolysis. This is a common method for synthesizing phenols.

56. Based on its functional group and the number of carbon atoms, glucose is best classified as a:

ক) Aldopentose খ) Aldohexose

গ) Ketopentose ঘ) Ketohexose

Answer: Aldohexose

Explanation: The correct answer is B. Glucose has an aldehyde functional group at C-1, making it an aldose. It also contains six carbon atoms in its backbone, making it a hexose. Therefore, it is an aldohexose.

57. Two monosaccharides that are non-superimposable mirror images of each other are called:

ক) Epimers খ) Anomers

গ) Enantiomers ঘ) Diastereomers

Answer: Enantiomers

Explanation: The correct answer is C. Enantiomers are stereoisomers that are perfect, non-superimposable mirror images, like a left hand and a right hand. In carbohydrates, this is represented by the D- and L- configurations. Epimers (A) and anomers (B) are types of diastereomers (D), which are stereoisomers that are not mirror images of each other.

58. The glycosidic bond that links the two glucose units in maltose is:

ক) α(1→4) খ) β(1→4)

গ) α(1→6) ঘ) α(1→2)

Answer: ক) α(1→4)

Explanation: The correct answer is A. Maltose, also known as malt sugar, is a disaccharide formed from two units of α-D-glucose joined by a covalent α(1→4) glycosidic bond. This means the anomeric carbon (C-1) of the first glucose is linked to the hydroxyl group on C-4 of the second glucose.

59. Starch is composed of amylose and amylopectin. The primary structural difference is that:

ক) Amylose is branched, while amylopectin is linear.

খ) Amylopectin is branched, while amylose is a linear polymer.

গ) Amylose contains β-glycosidic bonds, while amylopectin contains α-glycosidic bonds.

ঘ) Amylose is a polymer of fructose, while amylopectin is a polymer of glucose.

Answer: খ) Amylopectin is branched, while amylose is a linear polymer.

Explanation: The correct answer is B. Amylose is an unbranched, helical polymer of glucose units linked by α(1→4) glycosidic bonds. Amylopectin is the branched component, having a backbone of α(1→4) linkages with branch points created by α(1→6) glycosidic bonds every 24-30 residues.

60. Which of the following is a defining characteristic of mucopolysaccharides (glycosaminoglycans)?

ক) They are highly branched polymers of glucose.

খ) They consist of repeating disaccharide units containing an amino sugar.

গ) They are neutral molecules found primarily in plant cell walls.

ঘ) They are indigestible by all known organisms.

Answer: খ) They consist of repeating disaccharide units containing an amino sugar.

Explanation: The correct answer is B. Mucopolysaccharides, now more commonly called glycosaminoglycans (GAGs), are long, unbranched polysaccharides consisting of repeating disaccharide units. Each unit typically contains an amino sugar (like N-acetylglucosamine) and a uronic acid (like glucuronic acid). Their negative charges and ability to bind water make them excellent lubricants and shock absorbers in connective tissues.

61. The highly branched structure of glycogen is a key advantage for its role in energy storage because:

ক) It makes the molecule more compact and soluble than an unbranched polymer.

খ) It provides a vast number of non-reducing ends for rapid glucose release.

গ) It allows for the formation of strong, water-insoluble structural fibers.

ঘ) It prevents the molecule from being digested by amylase.

Answer: খ) It provides a vast number of non-reducing ends for rapid glucose release.

Explanation: The correct answer is B. Enzymes like glycogen phosphorylase release glucose units from glycogen by acting on its ends. The numerous branches create a multitude of non-reducing ends. This allows for the simultaneous release of many glucose molecules, providing a rapid burst of energy when the body needs it, such as during exercise. While it also contributes to compactness (A), the primary metabolic advantage is the rapid mobilization of glucose.

62. Which of the following amino acids is classified as basic?

ক) Aspertate খ) Leucine

গ) Lysine ঘ) Serine

Answer: Lysine

Explanation: The correct answer is C. Lysine has a side chain containing a primary amino group, which accepts a proton and is positively charged at physiological pH (around 7.4), making it basic. Aspartate (A) is acidic, Leucine (B) is nonpolar (hydrophobic), and Serine (D) is polar, uncharged.

63. The primary structure of a protein is defined by the:

ক) Sequence of amino acids

খ) Hydrogen bonds forming α-helices

গ) Three-dimensional folding of the chain

ঘ) Assembly of multiple subunits

Answer: ক) Sequence of amino acids

Explanation: The correct answer is A. The primary (1°) structure is the unique linear sequence of amino acids joined by peptide bonds. This sequence dictates all higher levels of protein structure and, ultimately, its function.

64. An "essential" amino acid is one that:

ক) Is critical for forming peptide bonds.

খ) Must be obtained from the diet.

গ) Is synthesized by the body as needed.

ঘ) Is charged at physiological pH.

Answer: খ) Must be obtained from the diet.

Explanation: The correct answer is B. The human body cannot synthesize essential amino acids (e.g., Phenylalanine, Valine, Tryptophan, Threonine, Isoleucine, Methionine, Histidine, Leucine, Lysine) de novo. Therefore, they are an essential component of the diet.`

65. At a pH equal to its isoelectric point (pI), an amino acid exists as a :

ক) A. Anion (net negative charge) খ) Cation (net positive charge)

গ) Zwitterion (net zero charge) ঘ) Uncharged molecule

Answer: গ) Zwitterion (net zero charge)

Explanation: The correct answer is C. The isoelectric point (pI) is the specific pH at which an amino acid has no net electrical charge. At this point, the amino group is protonated ($-NH_3^+$) and the carboxyl group is deprotonated ($-COO^-$), forming a dipolar ion known as a zwitterion.

66. A covalent disulfide bond can be formed between the side chains of two residues of which amino acid?

ক) Methionine খ) Serine গ) Cysteine ঘ) Alanine

Answer: Cystine

Explanation: The correct answer is C. A disulfide bond (-S-S-) is a covalent linkage formed from the oxidation of the sulfhydryl or thiol groups (-SH) on the side chains of two cysteine residues. This bond is crucial for stabilizing the tertiary structure of many secreted proteins.

67. Which of the following amino acids has an aromatic R-group containing a hydroxyl group?

ক) Phenylalanine খ) Tyrosine গ) Tryptophan ঘ) Histidine

Answer: Tyrosine

Explanation: The correct answer is B. Tyrosine has a side chain consisting of a benzene ring with a hydroxyl group attached (a phenol group), making it both aromatic and polar. Phenylalanine (A) is aromatic but nonpolar, and Tryptophan (C) has a bulkier indole ring.

68. The binding of one O_2 molecule to hemoglobin enhances the binding of subsequent O_2 molecules. This is an example of:

ক) The Bohr effect খ) Cooperative binding

গ) Competitive inhibition ঘ) A primary structure effect

Answer: Cooperative binding

Explanation: The correct answer is B. This phenomenon is called cooperative binding, an example of allostery. The binding of oxygen to one subunit induces a conformational change in the entire hemoglobin tetramer, increasing the affinity of the remaining subunits for oxygen.

69. Which of the following carbohydrates is a non-reducing sugar?

ক) Sucrose খ) Lactose

গ) Maltose ঘ) Glucose

Answer: Sucrose

Explanation: The correct answer is A. A sugar is "reducing" if its anomeric carbon is free to form an open-chain aldehyde. In sucrose, the glycosidic bond links the anomeric carbon of glucose (C-1) and the anomeric carbon of fructose (C-2). Since both anomeric carbons are locked in the bond, the rings cannot open, and the sugar is non-reducing.

70. The characteristic ultraviolet (UV) absorbance of proteins at 280 nm is primarily due to:

ক) Alanine and Valine
খ) The peptide bond
গ) Tryptophan and Tyrosine
ঘ) Proline residues

Answer: Tryptophan and Tyrosine

Explanation: The correct answer is C. The aromatic side chains of Tryptophan and Tyrosine contain conjugated ring systems that strongly absorb UV light around 280 nm. Tryptophan has a much higher absorbance than tyrosine. This property is widely used to quickly estimate the concentration of a protein solution.

71. At physiological pH, which of the following pairs of amino acid side chains could form a salt bridge (ionic bond)?

ক) Serine and Threonine
খ) Aspartate and Lysine
গ) Leucine and Isoleucine
ঘ) Cysteine and Glycine

Answer: Aspartate and Lysine

Explanation: The correct answer is B. Salt bridges are electrostatic attractions between oppositely charged groups. At pH ~7.4, the acidic side chain of Aspartate is deprotonated ($-COO^-$), carrying a negative charge, while the basic side chain of Lysine is protonated ($-NH_3^+$), carrying a positive charge.

72. In the laboratory technique SDS-PAGE, proteins are separated almost exclusively based on their:

ক) Native charge
খ) Molecular mass
গ) Solubility in water
ঘ) Three-dimensional shape

Ans: Molecular Mass

Explanation: In SDS-PAGE, the separation of proteins by molecular mass is made possible by two key components: the detergent **SDS** and the **polyacrylamide gel**.

- **Sodium Dodecyl Sulfate (SDS):** This detergent is a crucial element. It binds to the hydrophobic regions of proteins, causing them to **denature** (unfold into linear chains) and become uniformly coated with a strong negative charge. This step is essential because it eliminates the influence of a protein's native charge and three-dimensional shape on its migration. Every protein, regardless of its original charge, now has a consistent negative charge-to-mass ratio.

73. Which of the following is a derived lipid?

ক) Triglyceride
খ) Phospholipid
গ) Cholesterol
ঘ) Glycolipid

Ans: Cholesterol

Explanation: Derived lipids are substances obtained by hydrolysis of simple or complex lipids, such as cholesterol, steroid hormones, and fat-soluble vitamins.

74. Which of the following lipids contain carbohydrate moieties?

ক) Glycolipids
খ) Phospholipids
গ) Glycoprotein
ঘ) Waxes

Answer: Glycolipids

Explanation: Glycolipids are lipids containing sugar residues (e.g., cerebrosides, gangliosides) and are important in cell recognition.

75. Which lipid-derived compound functions as a hormone?

ক) Cholesterol খ) Steroid

গ) Phospholipid ঘ) Triglyceride

Answer: b) Steroid

Explanation: Steroid hormones (e.g., cortisol, estrogen, testosterone) are derived from cholesterol.

76. Lipoproteins are responsible for:

ক) Synthesis of triglycerides খ) Transport of lipids in blood

গ) Hydrolysis of phospholipids ঘ) Breakdown of cholesterol

Answer: b) Transport of lipids in blood

Explanation: Lipoproteins (HDL, LDL, VLDL) transport hydrophobic lipids through the aqueous bloodstream.

77. Which test is used to detect unsaturation in oils?

ক) Molisch's test খ) Iodine value test

গ) Biuret test ঘ) Ninhydrin test

Answer: b) Iodine value test

Explanation: The iodine number measures the degree of unsaturation (double bonds) in fats and oils.

78. A high saponification number indicates:

ক) Longer fatty acid chains খ) Shorter fatty acid chains

গ) High unsaturation ঘ) Presence of cholesterol

Answer: b) Shorter fatty acid chains

Explanation: Saponification number is inversely related to fatty acid chain length.

79. Which of the following is an essential fatty acid?

ক) Oleic acid খ) Linoleic acid

গ) Palmitic acid ঘ) Stearic acid

Answer: b) Linoleic acid

Explanation: Linoleic, linolenic, and arachidonic acids are essential fatty acids required in diet.

80. Which of the following fatty acids is NOT essential?

ক) Linolenic acid খ) Arachidonic acid

গ) Oleic acid ঘ) Linoleic acid

Answer: c) Oleic acid

Explanation: Oleic acid is a monounsaturated fatty acid that can be synthesized by the body.

81. Which feature is characteristic of the B-form of the DNA double helix?

ক) It is a left-handed helix.

খ) The base pairs are tilted significantly with respect to the helix axis

গ) It has a wide, shallow minor groove and a narrow, deep major groove.

ঘ) It is the most common physiological form of DNA.

Answer: D

Explanation: The B-DNA is the classic Watson-Crick model and is the predominant form in the cell under physiological conditions. It is a right-handed helix with distinct major and minor grooves, and its base pairs are nearly perpendicular to the helix axis. Z-DNA is left-handed, and A-DNA has tilted base pairs.

82. What is a G-quadruplex?

ক) A four-stranded DNA structure formed in guanine-rich sequences.

খ) A complex of four histone proteins.

গ) A DNA-RNA hybrid with four strands

ঘ) A special structure found only in viral RNA.

Answer: A

Explanation: A G-quadruplex (or G4) is a secondary structure formed in nucleic acid sequences that are rich in guanine. It consists of a square arrangement of four guanine bases (a G-tetrad) stabilized by Hoogsteen hydrogen bonds, with these tetrads stacked on top of each other. They are often found in telomeres and promoter regions.

83. Which type of RNA is the most abundant in a typical eukaryotic cell?

ক) messenger RNA (mRNA)

খ) transfer RNA (tRNA)

গ) ribosomal RNA (rRNA)

ঘ) microRNA (miRNA)

Answer: C

Explanation: Ribosomal RNA (rRNA) is the most abundant type, making up over 80% of the total cellular RNA. This is because it is a stable, structural component of ribosomes, and a cell needs a vast number of ribosomes to carry out protein synthesis.

84. The structure of transfer RNA (tRNA) is often described as a cloverleaf in 2D. Which region of the tRNA molecule binds to the amino acid?

ক) The anticodon loop

খ) The TΨC loop

গ) The D loop

ঘ) The 3' acceptor stem

Answer: D

Explanation: The amino acid is covalently attached to the free 3'-hydroxyl group of the adenosine residue at the end of the 3' acceptor stem. The sequence at this end is typically CCA. The anticodon loop pairs with the codon on the mRNA.

85. What modification is typically found at the 5' end of a eukaryotic mRNA molecule?

ক) A poly(A) tail

খ) A 7-methylguanosine cap

গ) A sequence of introns

ঘ) An amino acid

Answer: B

Explanation: Eukaryotic pre-mRNAs undergo processing, which includes the addition of a 7-methylguanosine cap to the 5' end. This cap is added via an unusual 5'-5' triphosphate linkage

and is critical for mRNA stability, export from the nucleus, and initiation of translation. The poly(A) tail is at the 3' end.

86. What is the approximate energy value (caloric value) of one gram of protein?

ক) 4 kcal
খ) 9 kcal
গ) 7 kcal
ঘ) 2 kcal

Answer: ক) 4 kcal

Explanation: The approximate energy values are: carbohydrates, 4 kcal/g; proteins, 4 kcal/g; and fats, 9 kcal/g.

87. Which type of fat is considered the most heart-healthy?

ক) Saturated fat
খ) Trans fat
গ) Monounsaturated fat
ঘ) Hydrogenated fat

Answer: গ) Monounsaturated fat

Explanation: Monounsaturated fats, found in foods like avocados and olive oil, are considered beneficial for heart health as they can help lower LDL ("bad") cholesterol levels. Saturated and trans fats are generally considered unhealthy.

88. The specific dynamic action (SDA) of food is the energy expenditure required for:

ক) Digestion, absorption, and assimilation of food
খ) Basal metabolic activities
গ) Physical activity
ঘ) Maintaining body temperature

Answer: ক) Digestion, absorption, and assimilation of food

Explanation: SDA, also known as the thermic effect of food (TEF), is the metabolic increase that occurs after eating. It represents the energy cost of processing food for use and storage.

89. The respiratory quotient (RQ) is a ratio used to estimate which of the following?

ক) Basal metabolic rate
খ) Respiratory rate
গ) Energy expenditure from carbohydrate vs. fat
ঘ) Tidal volume

Answer: গ) Energy expenditure from carbohydrate vs. fat

Explanation: The RQ is the ratio of carbon dioxide produced to oxygen consumed, which indicates which macronutrient is being metabolized for energy.

90. A negative nitrogen balance indicates:

ক) Protein intake is equal to protein excretion
খ) Protein intake is greater than protein excretion
গ) Protein intake is less than protein excretion
ঘ) The body is in a state of muscle building

Answer: গ) Protein intake is less than protein excretion

Explanation: A negative nitrogen balance occurs when the body excretes more nitrogen than it consumes, indicating a net loss of body protein.

91. Which of the following is a function of fat in the body?

ক) Regulation of blood sugar

খ) Facilitation of digestion

গ) Providing insulation and protection for organs

ঘ) Acting as a primary solvent for nutrients

Answer: গ) Providing insulation and protection for organs

Explanation: Body fat serves as insulation to maintain body temperature and cushions vital organs.

92. SDA is highest for which of the following macronutrients?

ক) Carbohydrates খ) Fats

গ) Proteins ঘ) Alcohol

Answer: Proteins

Explanation: The SDA for protein is the highest, at approximately 20-30% of its caloric value, due to the complex metabolic processes required to break it down.

93. Which of the following is most essential in a balanced diet chart for a pregnant woman during the second trimester?

ক) Increased carbohydrate intake খ) Increased folic acid and iron intake

গ) High salt intake ঘ) Reduced protein requirement

Answer: b) Increased folic acid and iron intake

Explanation: During pregnancy, particularly in the 2nd trimester, demand for folic acid (to prevent neural tube defects) and iron (to support maternal blood volume and fetal growth) is significantly increased. Carbohydrates and proteins are also important, but iron and folic acid are critical.

94. Pellagra, characterized by dermatitis, diarrhea, and dementia, is caused by a deficiency of:

ক) Thiamine (B1) খ) Niacin (B3)

গ) Riboflavin (B2) ঘ) Pyridoxine (B6)

Answer: b) Niacin (B3)

Explanation: Pellagra occurs due to niacin deficiency. In regions where maize is the staple without proper processing, niacin deficiency may occur. Historically observed in poorer populations with limited dietary diversity.

95. The precursor of Vitamin A in the diet is:

ক) β-carotene খ) Ergosterol গ) Tocopherol ঘ) Retinol

Answer: a) β-carotene

Explanation: Plant-derived β-carotene is converted into retinal in the body and then to retinol (active Vitamin A).

96. Deficiency of Vitamin A leads to:

ক) Pellagra খ) Xerophthalmia
গ) Scurvy ঘ) Beriberi

Answer: b) xerophthalmia

Explanation: Vitamin A is essential for the formation of rhodopsin in the retina; deficiency causes nyctalopia (night blindness).

97. Deficiency of Vitamin K leads to:

ক) Anemia খ) Hemorrhage due to clotting defect
গ) Neurological symptoms ঘ) Pellagra

Answer: Hemorrhage due to clotting defect

Explanation: Vitamin K is needed for γ-carboxylation of clotting factors (II, VII, IX, X). Deficiency leads to impaired coagulation.

98. Thiamine deficiency results in:

ক) Scurvy খ) Beriberi
গ) Rickets ঘ) Megaloblastic anemia

Answer: Beriberi

Explanation: Thiamine deficiency causes dry and wet beriberi and Wernicke-Korsakoff syndrome, due to impaired carbohydrate metabolism.

99. Which vitamin acts as a coenzyme in carboxylation reactions?

ক) Vitamin K খ) Biotin (B7)
গ) Riboflavin (B2) ঘ) Pyridoxine (B6)

Answer: b) Biotin (B7)

Explanation: Biotin acts as a coenzyme in carboxylase enzymes, e.g., pyruvate carboxylase, acetyl-CoA carboxylase.

100. Coenzyme form of Vitamin B2 (Riboflavin) is:

ক) FMN and FAD খ) NAD+ and NADP+
গ) TPP ঘ) PLP

Answer: a) FMN and FAD

Explanation: Riboflavin (B2) is converted into flavin mononucleotide (FMN) and flavin adenine dinucleotide (FAD), which are electron carriers in redox reactions.

101. Which vitamin's active coenzyme is pyridoxal phosphate (PLP)?

ক) B1 খ) B2 গ) B6 ঘ) B12

Answer: c) B6

Explanation: Vitamin B6 (pyridoxine) is converted to PLP, a coenzyme in amino acid metabolism (transamination, decarboxylation).

102. An enzyme that catalyzes the transfer of electrons from a donor (reductant) to an acceptor (oxidant) belongs to which class?

ক) Transferases খ) Hydrolases
গ) Oxidoreductases ঘ) Lyases

Answer: Oxidoreductase

Explanation: Oxidoreductases (EC 1) are the class of enzymes that catalyze oxidation-reduction (redox) reactions. A common example is lactate dehydrogenase, which catalyzes the interconversion of pyruvate and lactate with the concomitant interconversion of NADH and NADH H+

103. DNA ligase joins two separate DNA fragments, a process that requires energy from ATP. This enzyme is classified as a:

ক) Isomerase
খ) Hydrolase
গ) Ligase
ঘ) Lyase

Answer: C

Explanation: Ligases (EC 6) catalyze the joining (ligation) of two molecules, a reaction that is coupled with the hydrolysis of a high-energy phosphate bond in ATP or another nucleotide. This energy input is required to form the new chemical bond, such as the phosphodiester bond formed by DNA ligase.

104. The "induced-fit" model of enzyme-substrate interaction, proposed by Daniel Koshland, suggests that the:

ক) Active site is a rigid, pre-shaped pocket for the substrate.
খ) Substrate binds to a random location on the enzyme surface.
গ) Binding of the substrate causes a conformational change in the active site for an optimal fit.
ঘ) Enzyme and substrate are perfect complements before any binding occurs.

Answer: C

Explanation: The induced-fit model refines the older "lock-and-key" theory. It posits that the active site is flexible. The initial binding of the substrate induces a subtle change in the enzyme's three-dimensional structure, optimizing the alignment of catalytic groups and strengthening the binding interaction, which facilitates catalysis.

105. The Michaelis constant, Km, is operationally defined as:

ক) The substrate concentration at which the reaction velocity is equal to Vmax.
খ) The maximum velocity divided by the total enzyme concentration.
গ) The substrate concentration at which the reaction velocity is half of Vmax.
ঘ) The rate constant for the dissociation of the enzyme-substrate complex.

Answer: C

Explanation: By definition, Km is the substrate concentration required for the enzyme to achieve half of its maximum velocity (Vmax/2). It is a characteristic property of an enzyme for a particular substrate and is an indicator of the affinity between them.

106. In competitive inhibition, the inhibitor molecule:

ক) Binds to a site on the enzyme other than the active site.
খ) Binds irreversibly to the active site, forming a covalent bond.
গ) Structurally resembles the substrate and binds reversibly to the active site.

ঘ) Binds only to the enzyme-substrate (ES) complex.

Answer: C

Explanation: A competitive inhibitor "competes" with the substrate for the same active site because it typically has a chemical structure similar to the substrate. This binding is reversible, and its effect can be overcome by increasing the substrate concentration, which will outcompete the inhibitor for access to the active site.

107. How does a pure non-competitive inhibitor affect the kinetic parameters of an enzyme?

ক) It increases Km and does not change Vmax.

খ) It decreases Vmax and does not change Km.

গ) It decreases both Km and Vmax.

ঘ) It does not change Km and does not change Vmax.

Answer: B

Explanation: A non-competitive inhibitor binds to an allosteric (non-active) site on the enzyme, regardless of whether the substrate is bound. This binding alters the enzyme's conformation, reducing its catalytic efficiency without affecting its ability to bind the substrate. As a result, Vmax is decreased, but the affinity for the substrate, and thus Km, remains unchanged.

108. The first step of the TCA cycle involves the formation of:

ক) Oxaloacetate খ) Citrate

গ) Succinyl-CoA ঘ) Fumarate

Answer: B) Citrate

Explanation: Acetyl-CoA combines with oxaloacetate to form citrate, catalyzed by citrate synthase.

109. The TCA cycle generates how many ATP equivalents per acetyl-CoA?

ক) 6 খ) 8 গ) 10 ঘ) 12

Answer: C) 10

Explanation:

3 NADH = 7.5 ATP

1 $FADH_2$ = 1.5 ATP

1 GTP = 1 ATP

Total = 10 ATP

110. Which enzyme catalyzes the rate-limiting step of the oxidative phase of PPP?

ক) Glucose-6-phosphatase খ) Glucose-6-phosphate dehydrogenase

গ) Transketolase ঘ) Transaldolase

Answer: B) Glucose-6-phosphate dehydrogenase

Explanation: This enzyme converts glucose-6-phosphate to 6-phosphoglucono-δ-lactone, producing NADPH.

111. The non-oxidative phase of PPP mainly involves:

ক) ATP production খ) Interconversion of sugars

গ) NADPH production ঘ) CO2 release

Answer: B) Interconversion of sugars

Explanation: This phase generates various sugars like ribose-5-phosphate and fructose-6-phosphate.

112. The urea cycle occurs primarily in the:

ক) Kidneys and cytosol
খ) Liver and mitochondria
গ) Muscle and cytosol
ঘ) Brain and mitochondria

Answer: খ) Liver and mitochondria

Explanation: (b) The urea cycle is a hepatic (liver) process. Its first two steps occur in the mitochondrial matrix, and the subsequent three steps occur in the cytosol.

113. The purpose of transamination is to:

ক) Remove the amino group as ammonia.

খ) Transfer an amino group from one amino acid to a keto acid, forming a new pair.

গ) Synthesize non-essential amino acids from ammonia.

ঘ) Decarboxylate amino acids to form neurotransmitters.

Answer: খ) Transfer an amino group from one amino acid to a keto acid, forming a new pair.

Explanation: Transamination is a reversible reaction that involves the transfer of an α-amino group from an amino acid to an α-ketoacid, resulting in a new amino acid and a new ketoacid. This is the primary mechanism for redistributing nitrogen.

114. The primary hormone that stimulates lipolysis in adipose tissue is:

ক) Insulin
খ) Glucagon
গ) Epinephrine
ঘ) Both b and c

Answer: ঘ) Both b and c

Explanation: Glucagon (during fasting) and epinephrine (during stress/exercise) activate hormone-sensitive lipase (HSL), promoting lipolysis. Insulin (a) has the opposite effect; it inhibits lipolysis and promotes fat storage.

115. The function of the carnitine shuttle system is to:

ক) Activate long-chain fatty acids.

খ) Transport long-chain fatty acyl-CoA molecules across the inner mitochondrial membrane.

গ) Synthesize carnitine from lysine.

ঘ) Transport short-chain fatty acids into the mitochondria.

Answer: খ) Transport long-chain fatty acyl-CoA molecules across the inner mitochondrial membrane.

Explanation: The inner mitochondrial membrane is impermeable to fatty acyl-CoA. The carnitine shuttle (involving CPT-I, translocase, and CPT-II) facilitates the transport of the acyl group from cytosolic CoA to mitochondrial CoA. Activation (a) happens before the shuttle. The shuttle is primarily for long-chain fatty acids; short/medium-chain (d) can diffuse in freely.

116. The final round of beta-oxidation for a palmitic acid (16:0) molecule yields:

ক) Two acetyl-CoA molecules
খ) One acetyl-CoA and one propionyl-CoA

গ) Two propionyl-CoA molecules ঘ) One acetoacetyl-CoA molecule

Answer: ক) Two acetyl-CoA molecules

Explanation: Palmitate (C16) is a saturated, even-chain fatty acid. It undergoes 7 cycles of beta-oxidation, each producing one acetyl-CoA. The 7th cycle cleaves the last 4-carbon unit into two acetyl-CoA molecules, making a total of 8 acetyl-CoA from the complete oxidation of one palmitate.

117. The complete oxidation of one molecule of palmitic acid (16:0) theoretically yields approximately how many molecules of ATP?

ক) 108 ATP খ) 32 ATP

গ) 129 ATP ঘ) 16 ATP

Answer: 108 ATP

Explanation: Calculation: 7 $FADH_2$ x 1.5 ATP = 10.5 ATP; 7 NADH x 2.5 ATP = 17.5 ATP; 8 Acetyl-CoA x 10 ATP/TCA cycle = 80 ATP. Total gross ATP = 108. Subtract 2 ATP equivalents used for activation, giving a net yield of ~106 ATP. Among the options, 108 is the closest gross value.

118. The primary substrate for ketogenesis is:

ক) Oxaloacetate খ) Acetyl-CoA

গ) Malonyl-CoA ঘ) Pyruvate

Answer: খ) Acetyl-CoA

Explanation: When beta-oxidation is high (e.g., during starvation/diabetes), large amounts of acetyl-CoA are produced. If oxaloacetate is depleted (for gluconeogenesis), acetyl-CoA cannot enter the TCA cycle and is diverted into the pathway of ketogenesis.

119. The committed step in fatty acid biosynthesis is catalyzed by:

ক) Acetyl-CoA carboxylase (ACC) খ) Fatty acid synthase (FAS)

গ) Carnitine palmitoyltransferase I (CPT-I) ঘ) Malic enzyme

Answer: ক)Acetyl-CoA carboxylase (ACC)

Explanation: Acetyl-CoA carboxylase catalyzes the irreversible carboxylation of acetyl-CoA to form malonyl-CoA. This is the first and key regulated step that commits acetyl-CoA to fatty acid synthesis. FAS (b) then uses malonyl-CoA to build the fatty acid chain.

120. The enzyme complex responsible for the de novo synthesis of palmitic acid (16:0) in the cytosol is:

ক) Acyl-CoA synthetase খ) Pyruvate dehydrogenase complex

গ) Fatty Acid Synthase (FAS) ঘ) Acetyl-CoA carboxylase (ACC)

Answer: গ) Fatty Acid Synthase (FAS)

Explanation: Fatty Acid Synthase is a large multi-enzyme complex that catalyzes all the reactions to convert acetyl-CoA and malonyl-CoA into palmitate. ACC (d) produces the malonyl-CoA substrate for FAS.

121. Mammals cannot synthesize fatty acids with double bonds beyond carbon 9. This means they are unable to synthesize:

ক) Palmitic acid (16:0)

খ) Oleic acid (18:1, Δ9)

গ) Linoleic acid (18:2, Δ9,12) and Alpha-linolenic acid (18:3, Δ9,12,15)

ঘ) Stearic acid (18:0)

Answer: গ) Linoleic acid (18:2, Δ9,12) and Alpha-linolenic acid (18:3, Δ9,12,15)

Explanation: Linoleic acid (omega-6) and alpha-linolenic acid (omega-3) have double bonds at positions beyond carbon 9 (e.g., at carbon 12 and 15). Mammals lack the desaturase enzymes to create these and must obtain them from the diet, making them essential fatty acids.

122. The rate-limiting step in cholesterol biosynthesis is catalyzed by:

ক) HMG-CoA reductase

খ) HMG-CoA synthase

গ) Mevalonate decarboxylase

ঘ) Squalene synthase

Answer: ক) HMG-CoA reductase

Explanation: HMG-CoA reductase converts HMG-CoA to mevalonate. This is the major point of regulation for the entire cholesterol synthesis pathway and is the target of statin drugs.

123. The primary function of bile salts in lipid digestion is to:

ক) Hydrolyze triglycerides

খ) Act as emulsifying agents to increase the surface area of lipid droplets

গ) Transport lipids into intestinal cells

ঘ) Activate pancreatic lipase

Answer: খ) Act as emulsifying agents to increase the surface area of lipid droplets

Explanation: Bile salts are amphipathic molecules that act as biological detergents. They emulsify dietary fats, breaking large lipid droplets into smaller ones, which greatly increases the surface area for enzymes like pancreatic lipase to act upon. They do not perform hydrolysis (a) but do help activate lipase (d) indirectly.

124. The role of HDL (High-Density Lipoprotein) is often described as:

ক) "Bad cholesterol" transport

খ) Reverse cholesterol transport

গ) Triglyceride delivery

ঘ) Fatty acid transport

Answer: খ) Reverse cholesterol transport

Explanation: HDL is known as "good cholesterol" because it mediates reverse cholesterol transport—it picks up excess cholesterol from peripheral tissues and arterial plaques and returns it to the liver for excretion.

125. Which of the following is a classic symptom of maple syrup urine disease (MSUD)?

ক) Enlarged liver

খ) Sweet-smelling urine

গ) Black urine on standing

ঘ) Yellowing of the skin

Answer: খ) Sweet-smelling urine

Explanation: MSUD is a metabolic disorder caused by a defect in the branched-chain α-keto acid dehydrogenase complex, which breaks down the branched-chain amino acids (BCAAs) leucine, isoleucine, and valine. The name "maple syrup urine disease" comes from the distinct sweet odor of the urine, sweat, and earwax of affected individuals due to the buildup of these keto acids.

126. Familial hypercholesterolemia is a genetic disorder caused by a defect in which of the following?

ক) Apolipoprotein B-100 synthesis
খ) LDL receptor activity
গ) LDL receptor gene
ঘ) Cholesterol ester transfer protein (CETP)

Answer: গ) LDL receptor gene

Explanation: Familial hypercholesterolemia (FH) is a genetic disorder caused by a mutation in the LDL receptor gene (or, less commonly, other genes involved in LDL metabolism). This defect results in a reduced ability to remove low-density lipoprotein (LDL), or "bad" cholesterol, from the blood.

127. The primary function of albumin in the blood is to:

ক) Transport oxygen
খ) Maintain osmotic pressure
গ) Aid in blood clotting
ঘ) Transport iron

Answer: B) Maintain osmotic pressure

Explanation: Albumin helps maintain colloidal osmotic pressure and prevents edema by retaining fluid within blood vessels.

128. Which plasma protein is essential for blood clotting?

ক) Albumin
খ) Fibrinogen
গ) Globulin
ঘ) Ferritin

Answer: B) Fibrinogen

Explanation: Fibrinogen is converted into fibrin during the coagulation process, forming a blood clot.

129. The normal pH range of blood is:

ক) 6.8–7.0
খ) 7.0–7.2
গ) 7.35–7.45
ঘ) 7.5–7.8

Answer: C) 7.35–7.45

Explanation: Human blood is slightly alkaline, maintaining a narrow pH range essential for enzyme activity and cellular functions.

130. The destruction of old red blood cells primarily occurs in the:

ক) Bone marrow
খ) Liver and spleen
গ) Kidneys
ঘ) Lymph nodes

Answer: B) Liver and spleen

Explanation: Macrophages in the liver and spleen phagocytose and break down old or damaged RBCs.

131. A person with blood group AB can receive blood from:

ক) Group A only
খ) Group B only
গ) Groups A, B, AB, and O
ঘ) Group O only

Answer: C) Groups A, B, AB, and O

Explanation: AB blood group individuals are universal recipients because they lack anti-A and anti-B antibodies.

132. Which blood group is considered the universal donor for RBC transfusion?

ক) A+ খ) AB- গ) O- ঘ) B+

Answer: C) O-

Explanation: O- blood lacks A, B, and Rh antigens, making it safe for transfusion to any recipient.

133. Which chamber of the heart pumps oxygenated blood to the systemic circulation?

ক) Right atrium
খ) Left atrium
গ) Right ventricle
ঘ) Left ventricle

Answer: D) Left ventricle

Explanation: The left ventricle pumps oxygen-rich blood into the aorta for systemic circulation.

134. Which enzyme is most commonly measured to diagnose a heart attack?

ক) Amylase
খ) Creatine kinase-MB (CK-MB)
গ) Lipase
ঘ) Urease

Answer: B) Creatine kinase-MB (CK-MB)

Explanation: CK-MB is released into the blood when heart muscle is damaged, serving as a diagnostic marker for MI.

135. Villi and microvilli are primarily found in the:

ক) Stomach
খ) Small intestine
গ) Large intestine
ঘ) Esophagus

Answer: B) Small intestine

Explanation: Villi and microvilli increase the surface area for nutrient absorption in the small intestine.

136. The main function of the large intestine is to:

ক) Digest carbohydrates
খ) Absorb water and electrolytes
গ) Absorb proteins
ঘ) Produce digestive enzymes

Answer: B) Absorb water and electrolytes

Explanation: The large intestine primarily absorbs water and salts, and forms feces.

137. Hydrochloric acid (HCl) in the stomach is secreted by:

ক) Chief cells
খ) Parietal cells
গ) Goblet cells
ঘ) Enterocytes

Answer: B) Parietal cells

Explanation: Parietal cells secrete HCl, which activates pepsinogen and kills harmful microorganisms.

138. Glucose is absorbed into intestinal epithelial cells by:

ক) Passive diffusion
খ) Facilitated diffusion
গ) Active transport with sodium
ঘ) Endocytosis

Answer: C) Active transport with sodium

Explanation: Glucose absorption involves sodium-dependent active transport via SGLT-1 transporters.

139. The structural and functional unit of the liver is:

ক) Hepatic artery
খ) Hepatocyte
গ) Lobule
ঘ) Sinusoid

Answer: C) Lobule

Explanation: The liver is made up of hexagonal lobules, each consisting of hepatocytes arranged around a central vein.

140. The functional unit of the lungs is the:

ক) Bronchiole
খ) Alveolus
গ) Trachea
ঘ) Pleura

Answer: B) Alveolus

Explanation: Alveoli are tiny air sacs where gas exchange between air and blood occurs.

141. The primary function of the glomerulus is:

ক) Secretion
খ) Reabsorption
গ) Filtration
ঘ) Excretion

Answer: C) Filtration

Explanation: The glomerulus filters blood plasma, initiating urine formation.

142. Hormones derived from amino acids include:

ক) Insulin and glucagon
খ) Thyroxine and epinephrine
গ) Testosterone and estrogen
ঘ) Aldosterone and cortisol

Answer: B) Thyroxine and epinephrine

Explanation: Amino acid–derived hormones are synthesized from tyrosine or tryptophan. Examples: thyroxine (T4), epinephrine, norepinephrine.

143. Which of the following is a peptide hormone?

ক) Cortisol
খ) Epinephrine
গ) Glucagon
ঘ) Thyroxine

Answer: C) Glucagon

Explanation: Peptide hormones are made of amino acid chains, such as glucagon, insulin, and growth hormone.

144. Paracrine signaling refers to:

ক) Hormone acting on the same cell that secreted it
খ) Hormone traveling long distances via blood
গ) Hormone acting on nearby target cells

ঘ) Hormone stored in vesicles before release

Answer: C) Hormone acting on nearby target cells

Explanation: Paracrine hormones act locally, affecting neighboring cells (e.g., growth factors).

145. Steroid hormones act by:

ক) Binding to surface receptors

খ) Activating second messenger systems

গ) Directly regulating gene transcription

ঘ) Phagocytosis

Answer: C) Directly regulating gene transcription

Explanation: Steroid hormones cross the cell membrane, bind to intracellular receptors, and modulate gene expression.

146. Which hormone stimulates spermatogenesis?

ক) LH খ) FSH গ) Testosterone ঘ) Estrogen

Answer: B) FSH

Explanation: FSH acts on Sertoli cells to promote sperm production.

147. G-protein coupled receptors are involved in:

ক) Steroid hormone signaling খ) Thyroid hormone signaling

গ) Peptide and catecholamine signaling ঘ) Nuclear receptor activation

Answer: C) Peptide and catecholamine signaling

Explanation: Most peptide hormones and catecholamines bind to GPCRs to trigger intracellular signaling cascades.

148. Insulin receptor is a type of:

ক) GPCR খ) Ion channel receptor

গ) Tyrosine kinase receptor ঘ) Nuclear receptor

Answer: C) Tyrosine kinase receptor

Explanation: Insulin binds to a tyrosine kinase receptor, triggering phosphorylation cascades.

149. Which of the following is secreted by the posterior pituitary?

ক) A) Growth hormone খ) ACTH

গ) Oxytocin ঘ) TSH

Answer: C) Oxytocin

Explanation: The posterior pituitary releases oxytocin and ADH, synthesized in the hypothalamus.

150. The target organ of TSH is:

ক) Adrenal gland খ) Thyroid gland

গ) Kidney ঘ) Liver

Answer: B) Thyroid gland

Explanation: TSH stimulates the thyroid gland to produce T3 and T4.

151. Deficiency of ADH leads to:

ক) Diabetes mellitus খ) Diabetes insipidus
গ) Goiter ঘ) Cushing's syndrome

Answer: B) Diabetes insipidus

Explanation: Lack of ADH causes excessive urine output and dehydration, characteristic of diabetes insipidus.

152. The posterior pituitary stores hormones made in the:

ক) Pituitary gland খ) Hypothalamus
গ) Thyroid gland ঘ) Pancreas

Answer: B) Hypothalamus

Explanation: ADH and oxytocin are produced in the hypothalamus and stored in the posterior pituitary.

153. Thyroid hormones primarily regulate:

ক) Blood pressure খ) Glucose uptake
গ) Basal metabolic rate (BMR) ঘ) Calcium absorption

Answer: C) Basal metabolic rate (BMR)

Explanation: Thyroid hormones increase BMR by stimulating energy production and oxygen consumption.

154. The storage form of thyroid hormones in the thyroid gland is:

ক) T4 খ) T3 গ) Thyroglobulin ঘ) Iodide

Answer: C) Thyroglobulin

Explanation: Thyroid hormones are stored in the colloid as part of the protein thyroglobulin

155. PTH increases calcium levels by:

ক) Increasing calcium absorption in intestines
খ) Increasing bone resorption
গ) Increasing kidney calcium reabsorption
ঘ) All of the above

Answer: D) All of the above

Explanation: PTH increases calcium through three mechanisms: intestinal absorption, bone resorption, and kidney reabsorption.

156. Which hormone maintains pregnancy?

ক) Estrogen খ) Progesterone
গ) Testosterone ঘ) LH

Answer: B) Progesterone

Explanation: Progesterone maintains the uterine lining and prevents contractions during pregnancy.

157. ALT (Alanine aminotransferase) is primarily found in:

ক) Heart খ) Liver
গ) Muscle ঘ) Kidney

Answer: B) Liver

Explanation: Alanine aminotransferase (ALT) is an enzyme that is most concentrated in the hepatocytes (liver cells). Its primary role is to help convert alanine, an amino acid, into pyruvate, which is a key step in producing cellular energy. When liver cells are damaged or inflamed, ALT is released into the bloodstream. Therefore, a blood test showing high levels of ALT is a very specific indicator of liver injury, commonly seen in conditions like hepatitis (viral or autoimmune), fatty liver disease, or damage from toxins like alcohol.

158. AST (Aspartate aminotransferase) is elevated in:

ক) Liver and heart damage
খ) Only liver disease
গ) Only kidney disease
ঘ) Only pancreas disease

Answer: A) Liver and heart damage

Explanation: Aspartate aminotransferase (AST) is similar to ALT but is less specific to the liver. It is found in high concentrations in the liver, heart (cardiac muscle), skeletal muscles, kidneys, and brain. While it is also elevated in liver damage, significant damage to heart muscle (as in a myocardial infarction, or heart attack) or skeletal muscle will also cause a sharp rise in blood AST levels. Because of its wide distribution, an elevated AST level must be interpreted alongside other clinical findings and lab tests (like ALT and CK) to pinpoint the source of the injury.

159. The "flipped LDH pattern" (LDH-1 > LDH-2) is characteristic of:

ক) Viral hepatitis
খ) Myocardial infarction
গ) Gout
ঘ) Kidney failure

Answer: B) Myocardial infarction

Explanation: Normally, the concentration of LDH-2 in the blood is greater than LDH-1. However, following a myocardial infarction, a large amount of LDH-1 is released from the damaged heart muscle. This influx of LDH-1 can raise its level above that of LDH-2, leading to a "flipped" pattern where LDH-1 > LDH-2. This finding is highly characteristic of a recent heart attack.

160. Acid phosphatase is elevated in:

ক) Prostate cancer
খ) Osteoporosis
গ) Diabetes
ঘ) Hepatitis

Answer: A) Prostate cancer

Explanation: Acid phosphatase (ACP) is an enzyme found in various tissues, but its highest concentration is in the prostate gland. When prostate cancer is present, particularly when it has metastasized (spread) beyond the prostate capsule, especially to the bones, large amounts of ACP are released into the blood. Therefore, elevated ACP levels are a strong indicator of advanced or metastatic prostate cancer and can be used to monitor the progression of the disease.

161. Alkaline phosphatase (ALP) is elevated in:

ক) Liver and bone diseases
খ) Diabetes

গ) Anemia ঘ) Lung diseases

Answer: A) Liver and bone diseases

Explanation: High ALP levels indicate liver disease (bile duct obstruction) or bone disorders (Paget's disease).

162. Calcium ions play a vital role in:

ক) Blood clotting খ) Muscle contraction

গ) Nerve conduction ঘ) All of the above

Answer: D) All of the above

Explanation: Calcium is essential for clotting, muscle function, and nerve transmission.

163. High cholesterol is a risk factor for:

ক) Hypothyroidism খ) Atherosclerosis

গ) Osteoporosis ঘ) Diabetes insipidus

Answer: B) Atherosclerosis

Explanation: Cholesterol is a waxy, fat-like substance essential for building cell membranes and producing hormones. A desirable total cholesterol level in the blood is less than 200 mg/dL. When cholesterol levels are too high, particularly LDL ("bad") cholesterol, it can deposit in the walls of arteries. This buildup, known as plaque, hardens and narrows the arteries in a process called atherosclerosis. Atherosclerosis is the underlying cause of most cardiovascular diseases, including heart attacks and strokes.

164. Hyperbilirubinemia results in:

ক) Jaundice খ) Rickets

গ) Gout ঘ) Hypocalcemia

Answer: A) Jaundice

Explanation: High bilirubin causes yellowing of the skin and eyes, known as jaundice.

165. Indirect bilirubin increases in:

ক) Hemolytic anemia খ) Bile duct obstruction

গ) Liver cirrhosis ঘ) Bone fracture

Answer: A)

Explanation: Indirect (Unconjugated) Bilirubin: This is the initial form, which is fat-soluble and not yet processed by the liver. In hemolytic anemia, red blood cells are destroyed at an abnormally high rate, overwhelming the liver's capacity to process bilirubin. This leads to a buildup of unconjugated (indirect) bilirubin in the blood.

166. Direct bilirubin is:

ক) Unconjugated

খ) Conjugated with glucuronic acid

গ) Produced from hemoglobin breakdown only

ঘ) Found only in stool

Answer: B) Conjugated with glucuronic acid

Explanation: Direct bilirubin is water-soluble, conjugated by the liver for excretion.

167. In sickle cell anemia, which amino acid is substituted?

ক) Valine for glutamic acid খ) Glutamic acid for valine

গ) Glycine for alanine ঘ) Lysine for tyrosine

Answer: A) Valine for glutamic acid

Explanation: Sickle cell anemia is caused by a point mutation in the gene that codes for the β-globin chain of hemoglobin (HBB gene).

Nature of the Mutation: Type of mutation: Missense mutation (single base substitution)

DNA change: The sixth codon of the β-globin gene changes from GAG → GTG.

GAG codes for glutamic acid

GTG codes for valine so, At position 6, valine replaces glutamic acid.

168. In sickle cell anemia, RBCs become sickle-shaped under:

ক) High oxygen tension খ) Low oxygen tension

গ) High glucose ঘ) Low glucose

Answer: B) Low oxygen tension

Explanation: In sickle anemia, body produces deformed Hemoglobin. This altered hemoglobin (HbS) is unstable. Under conditions of low oxygen tension, HbS molecules polymerize into long, rigid rods, forcing the red blood cells into a characteristic crescent or "sickle" shape. These sickled cells are fragile, block blood flow, and cause the symptoms of the disease.

169. HbA1c reflects:

ক) Instant blood glucose level খ) Average blood glucose over 2–3 months

গ) Glucose levels after meals ঘ) Urine glucose concentration

Answer: B) Average blood glucose over 2–3 months

Explanation: Glycated hemoglobin (HbA1c) is a form of hemoglobin that is chemically linked to glucose. The amount of HbA1c formed is directly proportional to the average concentration of glucose in the blood. Since red blood cells have a lifespan of about 120 days (3 months), the HbA1c level provides an excellent reflection of a person's average blood glucose control over the preceding 2 to 3 months, making it a crucial tool for managing diabetes.

170. The cholera toxin acts by:

ক) Blocking sodium absorption খ) Activating adenylate cyclase

গ) Inhibiting water reabsorption ঘ) Breaking down ATP

Answer: B) Activating adenylate cyclase

Explanation: The bacterium produces cholera toxin, which enters intestinal cells and irreversibly activates an enzyme called adenylate cyclase. This leads to a massive increase in intracellular cyclic AMP (cAMP), which in turn causes ion channels to secrete huge amounts of electrolytes (chloride, sodium, etc.) and water into the intestinal lumen.

171. Hemolytic jaundice is characterized by:

ক) Increased conjugated bilirubin খ) Increased unconjugated bilirubin

গ) Low bilirubin ঘ) Normal bilirubin

Answer: B) Increased unconjugated bilirubin

Explanation: Excess RBC breakdown overwhelms the liver, causing high unconjugated bilirubin.

172. The urine of alkaptonuria patients turns black due to:

ক) Uric acid
খ) Homogentisic acid oxidation
গ) Phenylalanine breakdown
ঘ) Hemoglobin breakdown

Answer: B) Homogentisic acid oxidation

Explanation: In Alkaptonuria homogentisic acid accumulates in the body. When this acid is excreted in the urine and exposed to air, it oxidizes and polymerizes to form a dark, black pigment, which is the hallmark sign of the disease.

173. A high ALP with normal bilirubin indicates:

ক) Bile duct obstruction
খ) Bone disease
গ) Hepatitis
ঘ) Kidney stones

Answer: B) Bone disease

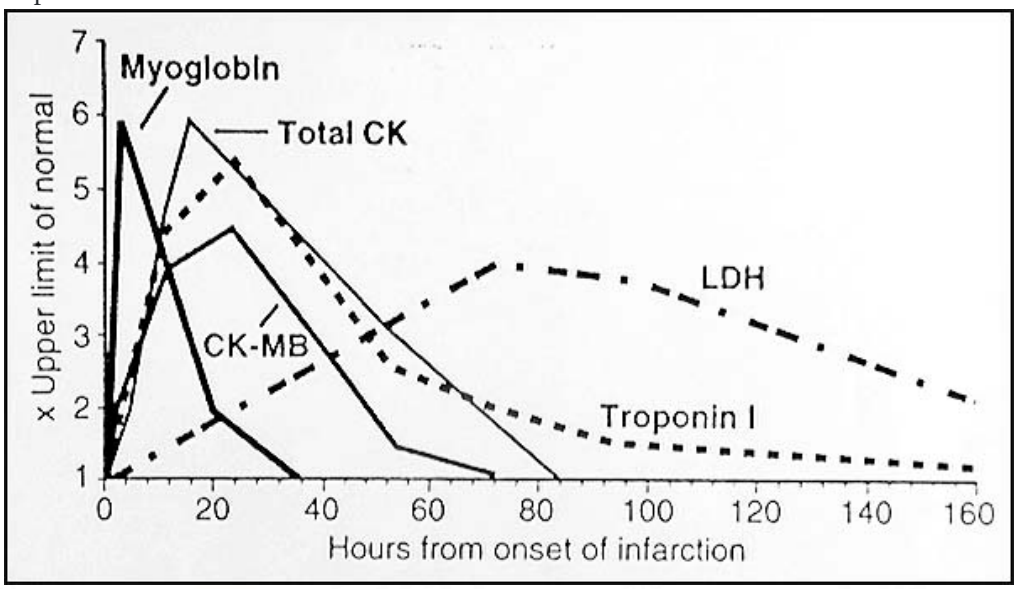
Explanation: High ALP but normal bilirubin suggests a bone-related problem, not a liver issue.

174. LDH remains elevated for how many days after a heart attack?

ক) 1 day
খ) 3 days
গ) 5-7 days
ঘ) 10 days

Answer: C) 5–7 days

Explanation:



175. Uric acid is the end product of:

ক) Protein metabolism
খ) Lipid metabolism
গ) Purine metabolism
ঘ) Carbohydrate metabolism

Answer: C) Purine metabolism

Explanation: Uric acid is formed from breakdown of purines like adenine and guanine.

176. Iron is primarily stored in the body as:

ক) Free iron
খ) Ferritin and hemosiderin
গ) Hemoglobin only
ঘ) Transferrin

Answer: B) Ferritin and hemosiderin

Explanation: Iron is stored in ferritin and hemosiderin within liver and bone marrow.

177. Obstructive jaundice is due to:

ক) Liver enzyme deficiency
খ) Bile duct blockage
গ) Low hemoglobin
ঘ) High albumin levels

Answer: B) Bile duct blockage

Explanation: Obstructive (or cholestatic) jaundice occurs when the flow of bile from the liver to the intestine is blocked. This blockage can be caused by gallstones, tumors, or inflammation. Because bile cannot be excreted, the water-soluble conjugated bilirubin backs up from the liver and re-enters the bloodstream, causing jaundice and often dark urine and pale stools.

178. Gout commonly affects:

ক) Children
খ) Young adults
গ) Middle aged men
ঘ) Elderly women

Answer: C) Middle-aged men

Explanation: Gout is a form of inflammatory arthritis caused by the crystallization of excess uric acid (hyperuricemia) within joints, most classically affecting the big toe. It is most common in middle-aged men, often due to a combination of genetic and lifestyle factors..

179. RNA primers are added by:

ক) DNA polymerase I
খ) Primase
গ) Helicase
ঘ) Ligase

Answer: B) Primase

Explanation: Primase, a type of RNA polymerase, synthesizes short RNA primers to initiate DNA replication.

180. Proofreading activity during DNA replication is provided by:

ক) 3’ → 5’ exonuclease activity of DNA polymerase
খ) 5’ → 3’ exonuclease activity
গ) Ligase activity
ঘ) Primase activity

Answer: A) 3’ → 5’ exonuclease activity of DNA polymerase

Explanation: DNA polymerase removes incorrectly paired nucleotides using its 3’ → 5’ exonuclease activity.

181. The coding strand of DNA is also known as:

ক) Template strand
খ) Sense strand
গ) Antisense strand
ঘ) tRNA strand

Answer: B) Sense strand

Explanation:

The sense strand has the same sequence as the mRNA (except for thymine replaced by uracil).

182. The Shine-Dalgarno sequence is found in:

ক) Eukaryotic mRNA খ) Prokaryotic mRNA
গ) tRNA ঘ) rRNA

Answer: B) Prokaryotic mRNA

Explanation: It helps align the ribosome with the start codon in prokaryotes.

183. The wobble hypothesis explains:

ক) Frameshift mutations খ) Flexibility in codon-anticodon pairing
গ) DNA repair ঘ) Splicing of introns

Answer: B) Flexibility in codon-anticodon pairing

Explanation:

The wobble position allows one tRNA to recognize multiple codons.

184. Which molecule is analyzed in Southern blotting?

ক) RNA খ) DNA গ) Protein ঘ) Lipid

Answer: B) DNA

Explanation:

Southern blot is for detecting specific DNA sequences.

185. A mutation that changes a codon to a stop codon is:

ক) Silent mutation খ) Missense mutation
গ) Nonsense mutation ঘ) Frameshift mutation

Answer: C) Nonsense mutation

Explanation:

It introduces a premature stop codon, truncating the protein.

186. Ethidium bromide is used for:

ক) DNA staining in gels খ) Protein sequencing
গ) mRNA translation ঘ) Mutation detection

Answer: A) DNA staining in gels

Explanation:

Ethidium bromide binds DNA and fluoresces under UV light.

187. The Sanger method uses:

ক) Restriction enzymes খ) dideoxynucleotides
গ) Ligase ঘ) RNA polymerase

Answer: B) dideoxynucleotides

Explanation:

Dideoxynucleotides terminate chain elongation for sequencing.

188. UAA, UAG, and UGA are:

ক) Start codons খ) Stop codons
গ) Promoter sequences ঘ) Introns

Answer: B) Stop codons

Explanation:

These are termination signals in translation.

189. The start codon for translation is:

ক) UGA খ) UAA গ) AUG ঘ) GUA

Answer: C) AUG

Explanation:

AUG codes for methionine and signals translation initiation.

190. Which DNA polymerase removes RNA primers in prokaryotes?

ক) A) DNA polymerase I খ) B) DNA polymerase II

গ) C) DNA polymerase III ঘ) D) Ligase

Answer: A) DNA polymerase I

Explanation:

DNA polymerase I has 5' → 3' exonuclease activity that removes RNA primers and replaces them with DNA.

191. Which vector can carry the largest DNA fragments?

ক) Plasmid খ) Cosmid গ) BAC ঘ) Phage vector

Answer: C) BAC

Explanation:

Bacterial Artificial Chromosomes (BACs) carry up to 300 kb of DNA.

192. An antibiotic resistance gene in a vector is used for:

ক) Selection of transformed cells খ) Cloning

গ) Restriction digestion ঘ) PCR

Answer: Selection of transformed cells

Explanation:

Only cells containing the plasmid grow in antibiotic-containing media.

193. Cosmids are a hybrid between:

ক) Plasmids and viruses খ) Plasmids and bacteriophage lambda

গ) Phages and BACs ঘ) BACs and YACs

Answer: B) Plasmids and bacteriophage lambda

Explanation:

Cosmids combine features of plasmids and lambda phages for cloning larger fragments.

194. The enzyme used in PCR is:

ক) DNA ligase খ) Taq polymerase

গ) RNA polymerase ঘ) Helicase

Answer: B) Taq polymerase

Explanation:

Taq polymerase is heat-resistant and derived from Thermus aquaticus.

195. Transformation involves:

ক) RNA transcription খ) Uptake of foreign DNA by a cell
গ) Protein folding ঘ) Replication only

Answer: B) Uptake of foreign DNA by a cell

Explanation:

Transformation introduces new genetic material into a host.

196. Calcium chloride in transformation helps by:

ক) Stabilizing DNA খ) Making cell membranes permeable
গ) Cutting DNA ঘ) Removing plasmids

Answer: B) Making cell membranes permeable

Explanation:

$CaCl_2$ increases membrane permeability, aiding DNA uptake.

197. The approximate number of human protein-coding genes is:

ক) 200,000 খ) 20,000–25,000
গ) 100,000 ঘ) 10,000

Answer: B) 20,000–25,000

Explanation:

Only about 1.5% of human DNA codes for proteins.

198. Shotgun sequencing involves:

ক) Cutting DNA into random fragments খ) Sequencing only coding DNA
গ) Using restriction enzymes exclusively ঘ) Sequencing RNA

Answer: A) Cutting DNA into random fragments

Explanation:

Fragments are later assembled computationally.

199. SNP stands for:

ক) Single Nucleotide Polymorphism খ) Sequence Nucleotide Protein
গ) Simple Nuclear Protein ঘ) Small Nucleotide Probe

Answer: A) Single Nucleotide Polymorphism

Explanation: SNPs are single base changes that contribute to genetic diversity.

200. The natural function of restriction enzymes in bacteria is to:

ক) Synthesize DNA খ) Defend against bacteriophages
গ) Produce mRNA ঘ) Promote recombination

Answer: B) Defend against bacteriophages

Explanation: Bacteria use restriction enzymes to cut foreign DNA from viruses as a defense mechanism.

The END